Too old to use IT?

User characteristics and the effectiveness of inclusive design for older users of public access systems

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Nomenclature

ATM	automated teller machines
BSI	British Standards Institute
EIDD	European Institute for Design and Disability
ICT	Information and Communication Technologies
SOC	Selection, Optimization and Compensation
TVM	ticket vending machines

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Abstract

Computer technology has permeated almost every sphere of daily living, bringing about many advantages - and challenges - for its users. This becomes particularly apparent for older people's use of public access systems like ticket vending machines (TVM), which should be „walk-up and use systems“ but often pose challenging problems for them. Are they too old to use IT?

Based on the notion that usability is not a product characteristic, but rather an interaction characteristic of product and user, this thesis aims to (a) improve the usability of a ticket vending machine (TVM) following two different approaches (teach or design) and to compare the resulting three TVM designs (original, video, wizard) regarding the usability criteria effectiveness, efficiency and satisfaction, and to (b) estimate the impact of age and age-correlated user characteristics on the successful use of these functionally equivalent TVM designs with a special focus on computer literacy.

In a two (age group: young, old) by three (experimental condition: control, video, wizard) factorial quasi experimental research design, 62 older (M=68 years) and 62 younger (M=25 years) participants solved the same eleven tasks in three different groups: The control group used a simulated TVM of the BVG (public transportation in Berlin, Germany), the video group watched a brief instructional video integrated into the same TVM before using it and the wizard group used a redesigned wizard interface instead. Measured user characteristics include computer literacy, control beliefs regarding technology, attitude towards TVM, computer anxiety and fluid intelligence.

Results indicate that video and wizard substantially improved the TVM usability, increasing effectiveness for the older groups from 52% to 80% and 88% respectively, reaching the performance level of the younger group using the original TVM. Using the wizard, age differences in effectiveness and satisfaction were eliminated. However, efficiency (time) differences remained between age groups. Hierarchical regression analysis revealed that user characteristics had a strong effect on effectiveness of BVG-TVM use, explaining 62% of the variance, but a weaker effect (36%) in the video condition and almost no effect (5%) in the wizard condition, indicating universal usability.

The results suggest that the integration of minimal video instruction or a task oriented wizard design can make public access systems truly universally usable with reasonable effort and that not chronological age itself predicts successful TVM use, but age related user characteristics, which can - and should - be measured and designed for.

Keywords: universal usability, older adults, public access systems, ICT, inclusive design, design for all, ticket vending machines

Zusammenfassung

Computer haben fast jeden Lebensbereich durchdrungen, was viele Vorteile - aber auch Herausforderungen - für ihre Nutzer mit sich bringt. Dies wird vor allem bei der Benutzung von Fahrkartenautomaten (FKA) oder anderer Technik im öffentlichen Raum deutlich, denn diese sollten beim Herantreten spontan benutzbar sein, stellen gerade ältere Benutzer aber oft vor Probleme. Sind sie zu alt, um Technik zu benutzen?

Basierend auf der Annahme, daß Gebrauchstauglichkeit keine Eigenschaft eines Produktes, sondern eine Eigenschaft der Interaktion zwischen Nutzer und Produkt darstellt, verfolgt diese Dissertation zwei Ziele. Zum einen soll die Gebrauchstauglichkeit eines Fahrkartenautomaten (FKA) verbessert werden, indem zwei einander ergänzende Ansätze angewandt werden (notwendiges Wissen vermitteln oder Produkt umgestalten) und die daraus entstehenden drei FKA-Varianten (Original, Video, Wizard) hinsichtlich der Kriterien der Gebrauchstauglichkeit Effektivität, Effizienz und Zufriedenstellung verglichen werden. Zum anderen soll der Einfluß des Alters und alterskorrelierter Benutzermerkmale auf die erfolgreiche Benutzung dieser funktional equivalenten FKA-Gestaltungsvarianten unter besonderer Berücksichtigung des Merkmals Computerwissen geschätzt werden.

In einem zwei faktoriellen quasi-experimentellen Versuchsplan mit zwei (Altersgruppe: jung, alt) mal drei (experimentelle Bedingung: Kontrolle, Video, Wizard) Faktorstufen lösten 62 ältere (M=68 Jahre) und 62 jüngere (M=25 Jahre) Versuchsteilnehmer die selben elf Aufgaben in drei verschiedenen Gruppen: Die Kontrollgruppe nutzte einen simulierten FKA der BVG (Berliner Verkehrsbetriebe), die Videogruppe sah ein kurzes Instruktionsvideo bevor sie den selben FKA nutzte und die Wizardgruppe nutzte statt dessen eine umgestaltete graphische Benutzungsschnittstelle. Zusätzlich wurden die Nutzermerkmale Computerwissen, Kontrollüberzeugungen im Umgang mit Technik, Einstellung gegenüber FKA und Computerängstlichkeit sowie zwei Maße der fluiden Intelligenz erfaßt.

Die Ergebnisse zeigen, daß die Gebrauchstauglichkeit des FKA mittels Video und Wizard erheblich verbessert werden konnte. So stieg die Effektivität für die älteren Gruppen von 52% auf 80% beziehungsweise 88% und erreichte damit das Leistungsniveau der jüngeren Nutzer des ursprünglichen FKA. Durch die Nutzung des Wizard konnten die Altersunterschiede in Effektivität und Zufriedenstellung vollständig eliminiert werden. Die zwischen den Altersgruppen bestehenden Unterschiede in Effizienz (gemessen nach Zeit) blieben jedoch bestehen. Eine hierarchische Regressionsanalyse zeigte, daß Nutzermerkmale einen starken Einfluß auf die effektive Benutzung des BVG-FKA hatten und 62% der gefundenen Varianz aufklärten. Dieser Effekt war deutlich schwächer in der Videobedingung (36%) und verschwand in der Wizard-Bedingung fast vollständig (5%), was als ein Zeichen für universelle Gebrauchstauglichkeit bewertet werden kann.

Die Ergebnisse legen nahe, daß Technik im öffentlichen Raum durch die Integration einer minimalen Videoinstruktion oder eines aufgabenorientierten Wizards mit angemessenem Aufwand universell nutzbar gestaltet werden kann und daß nicht das chronologische Alter die erfolgreiche Nutzung des FKA beeinflußt, sondern altersbezogene Nutzermerkmale, welche gemessen werden können und sollten, um eine nutzungsgerechte Gestaltung zu ermöglichen.

Schlagwörter: universal usability, alternsgerechte Gestaltung, altersdifferenzierte Gestaltung, Technik im öffentlichen Raum, IKT, inclusive design, design for all, Fahrkartenautomat

Erklärung zum Zustandekommen der Arbeit

Hiermit erkläre ich,

- dass ich die vorliegende Arbeit selbständig und ohne unzulässige Hilfe und ohne Benutzung anderer als der angegebenen Hilfsmittel und Quellen angefertigt habe,
- dass ich mich nicht anderwärts um einen Doktorgrad beworben habe und keinen Doktorgrad in dem Promotionsfach besitze, und
- dass ich die zugrundeliegende Promotionsordnung vom 03.08.2006 (Amtliches Mitteilungsblatt 34/2006) kenne.

Berlin, den 29.09.2014, Michael Sengpiel

Dedication

To my grandmother, who had a severe stroke amidst my studies.
I miss her stories. Tempus fugit.

Meiner Großmutter,
die einen schweren Schlaganfall erlitt, während ich mich dieser Arbeit widmete.
Ich vermisse Ihre Geschichten. Tempus fugit.

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Publications

1. Sengpiel, M., & Wandke, H. (2010). Compensating the effects of age differences in computer literacy on the use of ticket vending machines through minimal video instruction. Occupational Ergonomics, 9(2), 87–98.

2. Sengpiel, M. (submitted 2014). Teach or design? How older adults' use of ticket vending machines could be more effective. *Transactions on Accessible Computing*

3. Sengpiel, M. (submitted 2014). Too old to use IT? User characteristics and the effectiveness of inclusive design. *Universal Access in the Information Society*

Introduction

Much work for this thesis has been done as part of the "ALISA"-project, which was funded by the German Research Foundation (DFG) as part of the priority program „age-differentiated work systems“ (SPP 1184). This chapter briefly describes ALISA within SPP 1184 and gives on overview of the thesis.

The ALISA project within the priority program „age-differentiated work systems“

SPP 1184 started in 2005 and was set up to last six years, involving 19 universities and other German research institutions that conducted over 40 experiments with 2,000 participants and 50 field studies with 25,000 employees. Its goal was to develop models and methods companies could use to design and improve work systems and to offer aging employees better working and learning conditions (Schlick et al., 2013, p.6).

It was structured to address issues on seven levels from macro- to micro-ergonomics, based on the model by Luczak et al. (1987):

1. Sectors and value networks
2. Enterprises and companies
3. Cooperation in workgroups
4. Holistic activities and work forms
5. Tasks and workplaces
6. Sensorimotor control of tools
7. Autonomous organismic systems and the work environment

The „ALISA“-project of the Humboldt-University Berlin (Prof. Wandke) was integrated into level six, along with other research projects conducted by the RWTH Aachen University (Prof. Schlick), the Leibnitz Research Center (Prof. Heuer) and the Jacobs University Bremen (Prof. Godde).

ALISA focused on training and design measures to support older people in ICT use, conducting seven experiments with ticket vending machines (TVM). To research different training measures, a basic training program was compared with error guided training, worked examples and model based training (see Struve, 2009). To research measures of instruction and design, the existing BVG[1] TVM was compared to the same TVM complemented with video instruction and to a wizard redesign (see Sengpiel et al., 2013). These measures of instruction and design will be described in detail in this thesis.

Thesis overview

After introducing the ALISA project, the synopsis begins with a broad theoretical foundation for the social relevance of inclusive design and universal usability for an aging population. The second part of the theory section shifts focus from the macro to the micro level, from society to the individual, describing aging and technology use and a meta-model within life-span research called SOC (selection, optimization and compensation). It ends with age and cohort differences relevant for the design of usable technology and leads directly to the research questions and study overview described in the next section.

The goal of the following method section is to provide an overview repeating as little as possible from the submitted articles without compromizing comprehensibility and to

[1]Berliner Verkehrsbetriebe, the major public transportation provider in Berlin

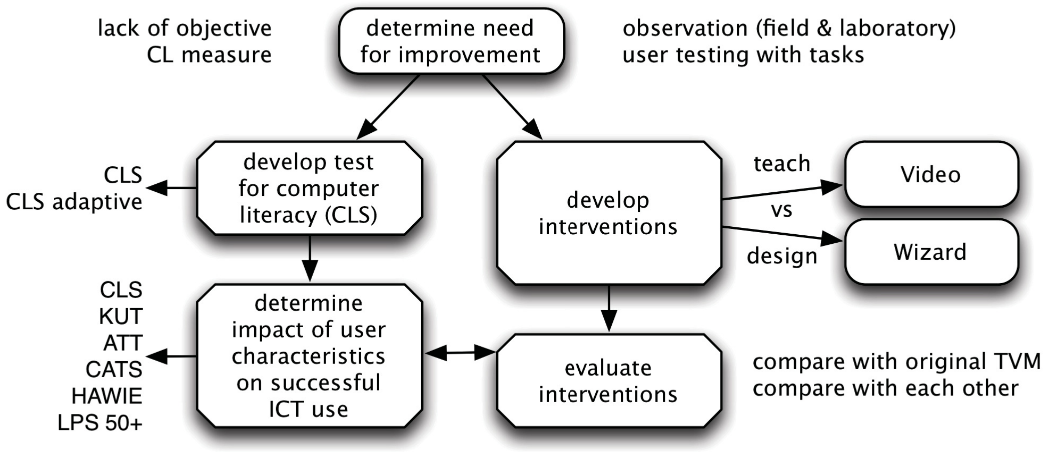

Figure 1. Dissertation overview

provide background information not found there. It starts with an overview of the research design and procedure and then describes briefly the design interventions video instruction and wizard redesign representing the independent variables. Then, the usability measures representing the dependent variables are briefly described, along with a section on CogTool modelling used to predict task execution times needed to calculate efficiency and a section on the Rating Scale Mental Effort (RSME) that has not been included in the articles due to space constraints. Finally, the control variables that were expected to influence TVM use are introduced. They include control beliefs regarding technology use, attitude toward ticket vending machines, computer anxiety, fluid intelligence and computer literacy, the latter filling an extra section describing the definition, operationalization and development of an objective knowledge test to measure it.

The results section combines the summary of main results for the three articles in two sections. First, the effect of the video instruction and wizard redesign to improve TVM usability are described and compared, with a focus on effectiveness of use. Second, the impact of age related user characteristics on successful TVM use are gauged and compared.

In the following section, these results are then discussed in the context of the theoretical background of the introduction and related research, leading to outlook and conclusion.

The appendix contains

A: the complete interview and testing manual used to guide the user testing, including all instructions, tasks and questionnaires, in the German original.

B: the prototype for the wizard redesign, made with OmniGraffle.

C: examples for CogTool results for the BVG and the wizard TVM, showing the sequence of interaction steps needed for an optimal solution as screenshots connected with arrows

D: the Computer literacy scale (CLS) manual in German, containing the questionnaire along with a brief description and instructions to calculate scale values.

E: the research articles this synopsis integrates, namely

article 1: with a focus on video instruction and the impact of computer literacy
=> Sengpiel, M., & Wandke, H. (2010). Compensating the effects of age differences in computer literacy on the use of ticket vending machines through minimal video instruction. Occupational Ergonomics, 9(2), 87–98.

article 2: with a focus on evaluation of the interventions video and wizard
=> Sengpiel, M. (submitted 2014). Teach or design? How older adults' use of ticket vending machines could be more effective. Transactions on Accessible Computing

article 3: with a focus on user characteristics predicting successful TVM use
=> Sengpiel, M. (submitted 2014). Too old to use IT? User characteristics and the effectiveness of inclusive design. Universal Access in the Information Society

Figure 1 provides a visualization of the dissertation overview. It begins on top with the observation of a need for improvement of the TVM that was based on the literature showing that public access systems such as ticket vending machines pose difficulties for many and older users in particular and on observations at train stations in Berlin (Butenhof, 2006)) and user testing comparing older and younger participants (Sengpiel et al., 2008).

Theory

Living with technology: Do artifacts have politics?

> "The penalty good men pay for indifference
> to public affairs is to be ruled by evil men."
> — Plato

In his short book "This is water", which is based on his commencement address to the Kenyon college class of 2005, David Foster Wallace (1962-2008) tells this story:

> There are these two young fish swimming along and they happen to meet an older fish swimming the other way, who nods at them and says "Morning, boys. How's the water?" And the two young fish swim on for a bit, and then eventually one of them looks over at the other and goes "What the hell is water?"

David Foster Wallace posits that the dreaded cliché of education being about "teaching you how to think" is not so much "about the capacity to think, but rather about the choice of what to think about" and concedes that we construct meaning from our experience while we are all at the center of (our construction of) the universe, yet he reminds us to be "just a little less arrogant" and to "have just a little critical awareness" about ourselves and our certainties that govern our daily living (Wallace, 2005).

Among the things we often take for granted are the artifacts that surround us. They are to us, in many ways, like water to the fish in Wallaces story. They are manifestations of human ingenuity that are deeply embedded in our culture and perhaps our very evolution (Ihde, 1990). They enable us to do things we could not do without them, they extend our range of potential actions. And yet by the same token, they can also restrict our actions, raising the pertinent question: "Do artifacts have politics?" (Winner, 1980).

Winner starts his article stating that "In controversies about technology and society, there is no idea more provocative than the notion that technical things have political qualities". He later illustrates this point with the parable of the bridges over the parkways on Long Island (New York), which were allegedly deliberately designed very low by Robert Moses, "the master builder of roads, parks, bridges, and other public works from the 1920s to the 1970s in New York", to "discourage the presence of buses on his parkways", evidently reflecting his "social-class bias and racial prejudice" (Winner, 1980, p.123). After all, "poor people and blacks, who normally used public transit, were kept off the roads because the twelve-foot tall buses could not get through the overpasses" (Winner, 1980, p.124).

He argues that most people will not think much about politics when they drive under a bridge and yet "the things we call "technologies" are ways of building order in our world. ... Consciously or not, deliberately or inadvertently, societies choose structures for technologies that influence how people are going to work, communicate, travel, consume, and so forth over a very long time" (Winner, 1980, p.127). Further examples he provides include inferior welding machines purchased to replace skilled welders who organized a union and handicapped people excluded from public life through artifacts, eg. in architecture.

Winner differentiates two kinds of choices to make regarding new technology (eg. atomic energy), the first being a yes-or-no question: "Are we going to develop and adopt the thing or not?" (Winner, 1980, p.127) and the second being an if-yes-then-how question:

What specific features in the design or arrangement of a technical system should be implemented? He adds that the first choice can already affect the second, because there are inherently political artifacts that require or are strongly compatible with certain social and political conditions: "Taking the most obvious example, the atom bomb is an inherently political artifact. As long as it exists at all, its lethal properties demand that it be controlled by a centralized, rigidly hierarchical chain of command closed to all influences that might make its workings unpredictable. The internal social system of the bomb must be authoritarian; there is no other way" (Winner, 1980, p.131).

Winners article is a "remarkable success story": It "has been quoted innumerable times in social studies of technology and planning" (Joerges, 1997, p. 5), even though his parable about the bridges of Robert Moses has been shown to be more of a convenient interpretation than an historically accurate account (Joerges, 1999, 1997).

Joerges (1997) argues, that Winners article is in itself an “artifact of politics”, because Winner seems to be interested in showing that artifacts embody politics and in delivering the moral message that thus using artifacts represents political action. He sees Winners bridge parable in the tradition of control theories (along with classical political theory, institutional theory, and early cybernetics) and contrasts them with contingency theories, where “social disorder and order are not seen as the product of planful, intentional action, but as the result of a conjunction of consequences of action. ... The great models are: evolutionary theory, chaos theory, and theories of self-organization" (Joerges, 1999, p. 17).

Joerges (1999, p. 18f) himself offers a third view, a “middle road between the two Cs of contingency and control, between instrumentation and unpredictable adaptation”, by seeing artifacts as “phenomena” or “boundary objects” in the interplay of representations and practices. In that view, artifacts themselves would not have politics, but they would be shaped by certain practices of people and would in turn shape them, much like a path through the grass that is frequently travelled will eventually become easier to travel on, thus affording people to take this path rather than another. The politics then, lies in the interplay of practice and embodiment (or representation), a view that can be subsumed under “technopragmatism” (German: “Technopragmatismus”), reconciling the complementary views of social constructivism and technological determinism (Rammert, 2007).

Rammert (2007) summarizes that technology can be seen as part of human culture, as resource of power between people and organizations, as means of control, e.g. in management and surveillance (see the current political debate over massive surveillance activities of the National Security Agency, NSA), as business advantage through innovation, as differentiator in international relations (eg. countries with and without atomic weapons), and more. And in all these cases, "Technology are not only tools and machines constructed by engineers, but at the same time social constructs of means and forms of working, researching, communicating and living in society. They are not just technical installations of physical material, energy and information, but at the same time materially mediated social institutions" (Rammert, 2007, quote translated by the author).

Ticket vending machines and public access systems

The political dimension of technology (or artifacts in general) is particularly relevant for public access systems, such as ticket vending machines (TVM) and automated teller machines (ATM). They are similar to bridges in that they provide access to larger sociotechnical systems that are highly relevant for its users: The ATM as a means to receive cash to buy goods and services, the TVM as a means to (legally) access the public transport system. They often originated as an alternative, e.g. to ticket counters and cash desks, so people could avoid using them. But as TVMs and ATMs replace these alternatives, the ability to use them changes from technological drift to technological imperative (Rammert, 2007), as avoiding them becomes more difficult and could eventually restrict societal participation.

This process is not unique to public access systems, as can be seen in the case of mobile phones that originated as an alternative to public and private landline phones and slowly if not completely replaced them, raising questions of usability and training for less experienced users (e.g. Bruder et al., 2013). Yet it is even more pronounced for users of public access systems, because they usually have little or no choice (e.g. they cannot choose to purchase a more “user-friendly” phone) and little time to learn or get used to the system in an environment suitable for learning (thinking of the line of commuters behind their back, eager to catch the next train). Thus the usability of public access systems (and the discrimination from a lack thereof) becomes an increasingly pressing practical issue and an increasingly socially relevant subject of research.

Public access systems that have received early attention include kiosks, such as multimedia systems in museums and libraries (e.g. Hardman, 1989) Automated Teller Machines (ATM, e.g. Rogers, Cabrera, et al. (1996), Rogers, Fisk, et al. (1996), Rogers & Fisk (1997)) and Ticket Vending Machines (TVM, e.g. Connell, 1998). Maguire (1999) has reviewed general user-interface design guidelines for public information kiosk systems, divided into defining user requirements, location and encouraging use, physical access, introduction and instruction, language selection, privacy, help, input (including touch screens), output (including the use of icons and feedback), structure and navigation, and customisation. He concludes that "The main concern in terms of user performance is whether users can complete tasks smoothly without too many errors, rather than their speed of performance" (Maguire, 1999, p. 15).

This dominance of effectiveness as a design goal can be considered a defining characteristic of public access systems or "walk-up and use systems": Anyone should be able to walk up to and use them successfully. While DIN EN ISO 9241 (DIN ISO, 2010) defines effectiveness, efficiency and satisfaction as usability criteria, it also defines it not as a characteristic of the technology itself, but of the interaction (see figure 2 on page 10) between the technology (product), the user (human), his or her goal (task) and the context of use (environment). Compared to systems used by highly trained professionals, such as airplane pilots flying an Airbus or secretaries typing letters with their office software, public access systems are often used by largely untrained and very diverse user groups for tasks that are similar in nature. As point in case, there are few expert users of a TVM and most of those who use it will be content to need five seconds more, as long as they get the desired ticket[2].

[2] As we learned in the ALISA project however, the provider of the TVM might value efficiency more, since for him the TVM constitutes an investment that needs to be profitable through ticket sales.

Public transportation in Berlin The TVM of the BVG (Berliner Verkehrsbetriebe) investigated in this thesis provides access to subway, S-Bahn, tram and bus lines covering about 2,300 kilometres in Berlin, the capital and biggest city of Germany, home to about 3.5 million people and covering an area of about 890 km^2, which is about nine times the size of Paris. Additionally, Berlin attracts many tourists: In 2012, almost eleven million people visited Berlin (visitBerlin, 2013). Since 1992, the City of Berlin is improving accessibility following the slogan: "Berlin for disabled people: the city is prepared." To honour the efforts of Berlin, the city has been rewarded with the Access City Award 2013 on December 3rd 2012 by the vice president of the European Commission Viviane Reding. The award covers four key areas of accessibility: built environment and public spaces, transport and related infrastructure, information and communication (including new technologies) and public facilities and services (European Commission, 2013; Senatsverwaltung für Stadtentwicklung und Umwelt - Berlin, 2012). To achieve successful use for the widest possible user group is the goal of design philosophies such as Design for All (DfA) and universal usability.

Universal design, access and usability

> "In a fair society, all individuals would have equal opportunity to participate in, or benefit from, the use of computer resources regardless of race, sex, religion, age, disability, national origin or other such similar factors." – ACM Code of Ethics[3]

The goal of successful use for the widest possible user group is shared by many institutions and design philosophies, carrying different names and varying perspectives that can be subsumed under three broad categories: design, access and use. Some of them shall be described here briefly.

Design. In the design category, three representatives will be introduced, starting with "Design for All", a term with roots in the 1950s and predominantly used in Europe, followed by "Universal Design" a similar term mainly used in the USA and Japan and "Inclusive Design" often considered to be a more practical approach.

"Design for All" has been an important issue before the widespread use of ICT (Information and Communication Technologies), with roots in Scandinavian functionalism of the 1950s and in ergonomic design of the 1960s. The European Institute for Design and Disability (EIDD[4]) developed their mission statement "Enhancing the quality of life through Design for All" soon after its establishment in 1993 and issued the "Stockholm Declaration" in 2004, summarizing the goal of Design for All as follows:

> "Across Europe, human diversity in age, culture and ability is greater than ever. We now survive illness and injury and live with disability as never before. Although today's world is a complex place, it is one of our own making, one in which we therefore have the possibility – and the responsibility – to base our designs on the principle of inclusion. Design for All is design for human diversity, social inclusion and equality. This holistic and innovative approach constitutes a

[3] http://www.acm.org/about/code-of-ethics
[4] www.designforalleurope.org

> creative and ethical challenge for all planners, designers, entrepreneurs, administrators and political leaders..." (EIDD, 2004)

One year later, the International Conference "Culture for All", held in Berlin in May 2005, referred to "the significance of Design for All as a tool for achieving a thriving society based on human diversity, social inclusion and equality and reiterating the principles enshrined in EIDD Stockholm Declaration, adopted on 9 May 2004" and to "the right proclaimed in Article 27.1 of the Universal Declaration of Human Rights, 1948, which reads:

> "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits" (EIDD, 2005).

"Universal Design" is a term very similar to "DfA" that is mainly used in the USA and Japan. It originated in architecture, coined by Ron Mace in the 1970s, and is described as

> "the process of creating products (devices, environments, systems, and processes) which are usable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumsfances), as is commercially practical" (Vanderheiden & Tobias, 2000, p. 6-19).

Similarly, the "United Nations Convention on the Rights of Persons with Disabilities" defines "Universal Design" as the "design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design" (United Nations, 2006)[5]. Vanderheiden & Tobias (2000, p. 6-19) differentiate two major components of "Universal Design":

1. "Designing products so that they are flexible enough that they can be directly used (without requiring any assistive technologies or modifications) by people with the widest range of abilities and circumstances as is commercially practical given current materials, technologies and knowledge" and

2. "Designing products so that they are compatible with the assistive technologies that might be used by those who cannot efficiently access and use the products directly."

They conclude from their own research that of the "many factors affecting a company's choice to adopt universal design, only two seem to have any permanent or lasting effect. The first is regulation... The second major factor is high profit." (Vanderheiden & Tobias, 2000, p. 6-21). This finding was confirmed by Dong et al. (2003) who found that "designers are reluctant to sacrifice the aesthetics of the brand to design for inclusion, but nevertheless would like to have practical tools to help them develop more inclusive solutions. For manufacturers, the key motivation for such practices is that of government regulation and legislation requiring the accessibility of products and services" (Dong et al., 2003, p.1).

Such government regulation could be based on grounds analogue to the "duty of care" for product liability, which was established on the case of Donoghue v Stevenson (UKHL 100, AC 562, 1932). Where May Donoghue had found a decomposed snail in the bottle from which she had just drank ginger beer in 1928, today many users find that public access systems they are obliged to use, such as TVMs, produce frustration rather than the desired

[5] `http://www.un.org/disabilities/convention/conventionfull.shtml`

tickets. Yet just like people drinking beer should be able to trust the manufacturer that there is no snail on the bottom of the bottle, people using public access systems should be able to trust the provider of these systems that they are carefully designed to match their needs and capabilities. It may be acceptable to sell mobile phones that can only be used successfully by 50% of potential users, but for public access systems such success rates should be deemed unacceptable. Thus, just as Sir David Terrence Puttnam has asked in a TED Talk in Febuary 2014: Does the media have a "duty of care"?, this raises the question: Do designers / providers of TVM have a “duty of care”? This question has already been answered affirmatively for other salient ICT, such as the Internet (Van Eijk et al., 2010).

“Inclusive Design” is defined by the British Standards Institute (BSI) as “The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialized design” (BSI, 2005). It shares the theme of making “mainstream products as accessible as possible to as many potential users as possible”, yet recognizes that “it is virtually impossible to design even a simple product that absolutely everyone can use” (Keates, 2007, p.14), appealing to some who critisize that Design for All and Universal Design may be too idealistic for practical purposes.

Access. Successful use requires access to technology, a fact that has already been acknowledged in the US telecommunications act of 1934 stating its goal

> “... to make available, so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex, a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges...” (US-Congress 1934, p. 1).

Access continues to be an important issue, as can be seen in its 2012 amendment (Congress, 2013) and current examples such as the “One laptop per child” program[6], trying to provide children in less developed regions with access to ICT, acknowledging its importance for education and empowerment: "Education is the great engine of personal development" (Nelson Rolihlahla Mandela, 1994).

While access in that sense is not so much an issue for TVM or other public access technology, the term “access” has also been used in a much wider sense. In his book "Designing for Accessibility”, Keates (2007, p.5) argues that the “product will have been designed to meet the demands of the task. However, the product itself will have it’s own set of demands that it places on the user. ... if those demands exceed the user’s capabilities, then the product is inaccessible and the user will not be able to perform the task." Figure 2 illustrates these interactions between the human, the task and the product and their respective capabilities and demands, based on Keates simplified version of the CREATE[7] Model of Aging and Technology that integrates user capabilities (cognitive, motor, perceptual, physical), task demands and technology demands in a triangular matching problem and provides a basis for fruitful research of the CREATE Group (Czaja et al., 2001) and

[6] http://one.laptop.org

[7] Center for Research and Education on Aging and Technology Enhancement, http://create-center.gatech.edu

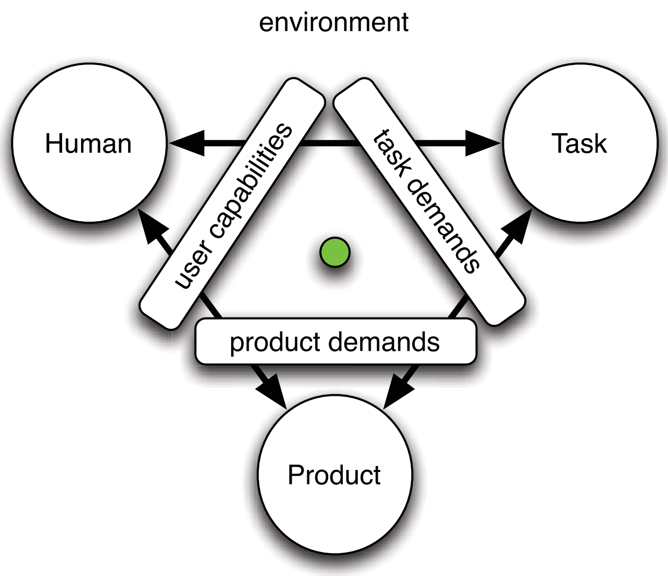

Figure 2. Map of interactions when using a product to accomplish a task (Figure based on Simeon Keates, 2007, p.6 and the CREATE Model of Aging and Technology, see Rogers & Fisk 2010)

others. It has been adopted widely to map the possible interactions when designing for the broadest possible range of users.

In this view, a product that is not usable becomes inaccessible, placing the concept of accessibility very close to the usability definition. Yet its focus on user capabilities directs attention to people with disabilities: According to the International Classification of Impairments, Disabilities and Handicaps (ICIDH) of the World Health Organisation, disability has been defined as "any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being" (WHO, 1980, 2001). Keates (2007) describes a model of disability in which desease, aging or accidents can lead to functional impairment, which can in turn lead to disability and concludes that "accessible design is good design", for ethical and economic reasons. However, universal access may be necessary but not sufficient.

Usability. "Universal Usability is the concept of designing computer interfaces that are easy for all users to utilize" (Lazar, 2007). In two articles published in quick succession, Shneiderman (1999) asks: "How can information and communications services be made usable for every citizen? Designing for experienced frequent users is difficult enough, but designing for a broad audience of unskilled users is a far greater challenge". He argues that accessibility is an important prerequisite, yet access does not suffice. While in 1934 there was concern of discrimination for having a telephone, today there is growing concern of not being able to use it.

Thus he calls for "universal usability" as design goal and argues that: „The term universal access has been applied to computing services, but the greater complexity of computing services means that access is not sufficient to ensure successful usage. Therefore universal usability has emerged as an important issue and a topic for computing research“ (Shneiderman, 1999; 2000, p.86). Shneiderman identifies three major challenges for universal usability: (1) technology variety (hard- & software), (2) user diversity (skill, knowledge, age, gender, disabilities, literacy, culture, income), and (3) gaps in user knowledge (what they know and what they need to know).

These gaps can be filled from two sides: While the user always has to learn to use a new technology successfully (unless there was something like "intuitive" use), the designer can support the user a) in the learning process (teach) and b) by reducing the amount of knowledge needed by the user (design). These two approaches have been investigated separately in this thesis, with an instructional video representing the teaching and a wizard representing the design approach. For practical applications, they can be combined to achieve the best results.

Shneiderman also suggests a criterion for universal usability that might be a good benchmark for public access systems such as the TVM investigated: “We can define universal usability as having more than 90% of all households as successful users of information and communications services at least once a week” (Shneiderman, 1999).

To summarize, there seems to be substantial overlap between the different terminology used. For example, the book “Universal Usability” edited by Jonathan Lazar (2007), subtitled “Designing Computer Interfaces for Diverse Users” contains a chapter on “The Why and How of Senior-Focused Design”, but also on children and vison impaired or blind users, or those with down syndrome or autism, which one might equally expect in a book on accessibility or Universal Design.

For this thesis, there seems to be no benefit in favoring one over the other. In fact, access, design and usability are seen as belonging together and the terms “for all”, universal and inclusive as sharing the goal of “successful use for the widest possible user group”. Thus, when focusing on usability aspects of the TVM, the term “universal usability” will be used and when focusing on design issues, the term “inclusive design” will be used, knowing full well that other terms might be equally suited.

Aging population

The aging population is currently a major concern for many countries, including Germany (United Nations 2010). A common indicator used by the United Nations is the number of people aged 60 years or over and their proportion of the total population (see Figure 3). In 2012, there were 810 million people aged 60 years or over in the world and

> “this number is projected to grow to more than 2 billion by 2050. At that point, older persons will outnumber the population of children (0-14 years) for the first time in human history. Asia has more than half (55 per cent) of the world’s older persons, followed by Europe, which accounts for 21 per cent of the total...
>
> One out of every nine persons in the world is aged 60 years or over. By 2050, one out of every five persons is projected to be in that age group. The proportion of the total population that is 60 years or older is much higher in the more developed regions than in the less developed regions: one in five persons in Europe; one in nine persons in Asia and Latin America and the Caribbean; and one in 16 persons in Africa” (United Nations 2012).

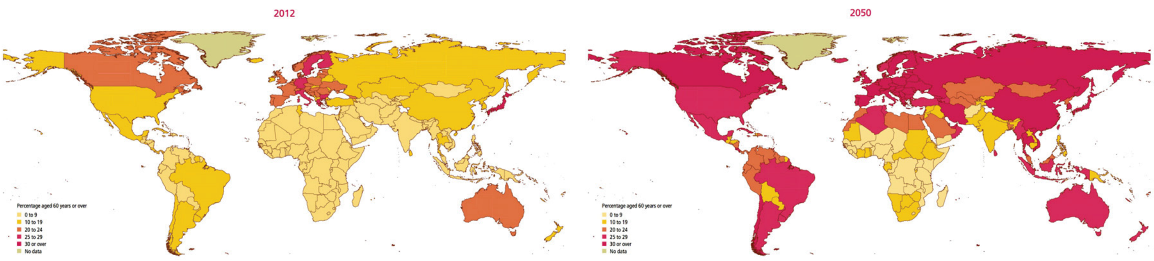

Figure 3. Percentage of the total population aged 60 years or over in 2012 (left) and 2050 (right), Figure taken from United Nations (2012)

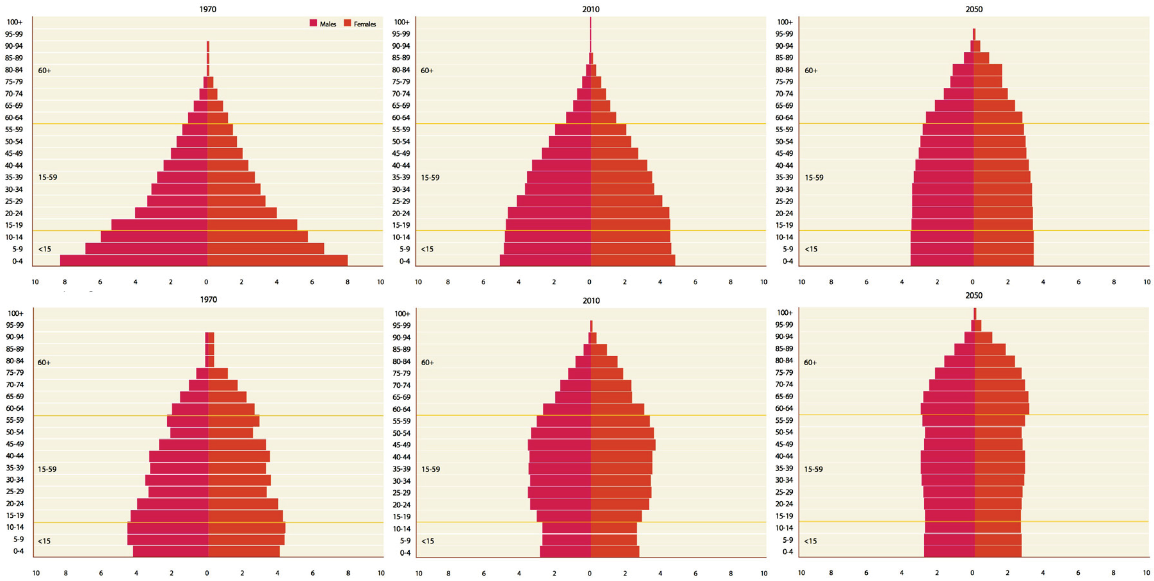

Figure 4. Age distribution of the world's population in the less (above) and more developed regions (below) for the years 1970 (left), 2010 (middle) and 2050 (right), Figure taken from United Nations (2012)

Figure 4 shows the age distribution of the world's population, separated in the less and more developed regions for the years 1970, 2010 and 2050. The population pyramids show the transition from the triangular shape to a more rectangular shape, associated with an older age structure (United Nations 2012). Comparing the four cohort sizes of 20 years (under 20, 20 to 39, 40 to 59 and above 60), the oldest cohort is projected to outnumber all others by 2070 worldwide and already by 2025 in the more developed countries (see Fig. 5, United Nations 2012).

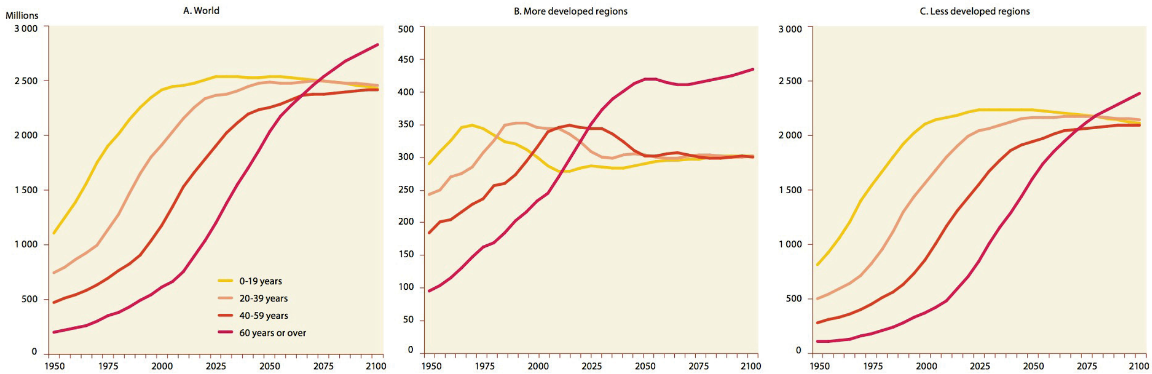

Figure 5. Population by 20-year-cohorts, worldwide (left), for more (middle) and less (right) developed regions, Figure taken from United Nations (2012)

Aging and technology use

Thou hast nor youth nor age
But as it were an after dinner sleep
Dreaming of both
— from "Measure for Measure" by William Shakespeare

The demographic change underscores the public interest currently invested in the issue of aging as an important challenge for society, effecting the entire world. Concurrently, the rapid development of ICT (Moore's Law, Moore, 2006, 1965) has made ICT virtually ubiquitous, creating wonderful new opportunities as well as tremendous challenges for its users. Mark Weiser, one of the pioneers in the field who coined the term "ubiquitous computing", envisioned that one day "machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods" (Weiser, 1991, p. 104).

However, many older users still experience ICT very differently. Even if computers are integrated in everyday life like water is for the fish, computers are still often alien to them and a source of frustration and avoidance. Yet, older adults are increasingly confronted with ICT, not just in public access systems. And they could benefit from using it, perhaps as much as or even more than younger adults. Aging and technology could be friends, not foes, as Nehmer et al. (2010) put it, yet that requires deliberate action from designers of such systems to accomodate their needs and capabilities.

One major application promising great benefits for older adults is the Internet (e.g. see Hanson, 2009). Its use shares some characteristics with TVM use, as it provides access to a large infrastructure and most websites are not used often, resulting in mostly novice users of the individual website with a very diverse range of prior experience. And Internet use is steadily increasing. Current data from the Pew research report 2014 on "Older adults and technology use" (A. Smith, 2014) indicates that Internet use for users aged 65+ has increased by about a 20% since 2010, now reaching 59%, even if still trailing the 86% of adults in general (see Fig. 6, left). Within the age group 65+, Internet use drops off quickly as age increases (see Fig. 6, right). Such numbers illustrate the importance of the

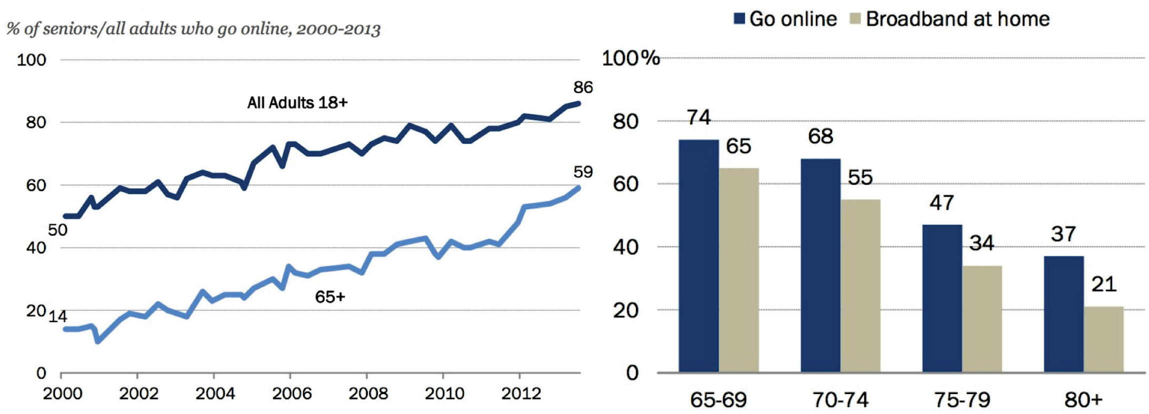

Figure 6. Internet adoption over time for all adults and those aged 65+ (left) and Internet use within the age group 65+ (right), figures taken from A. Smith (2014)

subject “Aging and technology use”, yet to understand the subject and make suggestions for improvements, we must turn to the individual perspective.

From the perspective of the individual, aging is very personal and most people don’t feel old or consider themselves to be. Hertzog et al. (2009, p. 3) report of a friend telling them that her 80-year-old grandmother dismissed the idea of living in an intermediate care facility saying: “Honey, I’m not old yet!” The very idea of aging evokes questions and themes of profound interest for most people, such as questions of life and death. Where do I come from? Where do I go? Why am I here and when will it all end? How do I maintain a good life for as long as possible? Even though aging has been studied extensively, it remains “one of the most inherently complex phenomena of the human sciences”, as Birren (1999) put it, fifty years after he published his first gerontological paper (Schaie & Willis, 2010). Therefore, only a few key topics immediately relevant for this thesis can be described here. For a comprehensive overview on the psychology of aging, Schaie & Willis (2010) can provide a good starting point. One key concept in aging research is that aging should be seen as a process rather than a status, a view central to so called “Life-span research on development and aging” (Schaie & Willis, 2010; P. B. Baltes, 1973).

Selection, Optimization and Compensation (SOC)

> I shall be telling this with a sigh
> Somewhere ages and ages hence:
> Two roads diverged in a wood, and I–
> I took the one less traveled by,
> And that has made all the difference.
> — from “The Road Not Taken” by Robert Frost

One of the core research questions on aging is, how people can maintain personal functioning, well-being and development over the life span despite steady loss of resources (B. B. Baltes & Dickson, 2001). SOC is the name of a meta-model within life-span research, providing a general framework that can represent the dynamics between developmental gains and losses across the life span (Riediger et al., 2006; P. B. Baltes & Baltes, 1990, 1989).

It starts with the premise that human resources are always limited, necessitating selection from alternatives throughout life. Such selections can be elective in response to new demands or tasks (e.g. choosing a major to study), or loss-based when resources are lost or expected to decrease (e.g. choosing to give up football after repeated injuries). Optimization improves efficiency of resource investment to increase functional levels (e.g. practicing piano). Compensation maintains a given level of functioning despite loss of resources (e.g. using a hearing aid). These three adaptive behaviors are part of every developmental process and their effective interplay is the hallmark of "adaptive development", defined by balancing the minimization of losses that impair effective functioning and the maximization of gains that promote growth and maintenance.

As a meta-model, SOC can have diverse applications. B. B. Baltes & Dickson (2001) provide examples for three areas of industrial-organizational psychology: work–family conflict, leadership, and organization-level functioning. And SOC can also be applied to universal usability and designing for older adults on at least two levels.

On a motivational level, it is important to acknowledge that it is a functional adaptation to reduce exploration of new technologies in old age and to concentrate on familiar things. This view is also consistent with "Socio-emotional Selectivity Theory" (SST; Carstensen, 1993; 1995) predicting that people's future time perspective (e.g. remaining time until death) impacts the prioritization of goals and motives. If the future time perspective is rather open ended, goals of learning and individual growth ("information seeking") are more important, if it is rather limited, goals of present psychological well-being ("emotion regulation") are more salient (Riediger et al., 2006; Carstensen, 1995). Thus in general, younger people will always embrace new technologies more than older people.

On a practical support level, SOC-strategies can be used to guide the development of new technologies. Selection could be used to reduce the number of functions. Optimization could be supported through training programs for important ICT interactions (e.g. Struve & Wandke, 2009; Hickman et al., 2007). Compensation could guide the design of the user interface to (a) reduce the technology demands on the user and (b) provide necessary capabilities (e.g. knowledge) in the context of use. This thesis follows an external compensation approach by (a) reducing the computer literacy necessary for successful interaction through a wizard-redesign and by (b) providing necessary computer literacy through a minimal video instruction.

Age differences and cohort differences

Age differences are well known in folklore. Wandke et al. (2012) discuss some popular myths including ability and motivational aspects and some that viciously suggest that the problem of designing for older adults will solve itself, because future generations of older people will be able to use new technology without problems. Since such myths have the power to be self-fulfilling, research is obliged to provide the facts to confront them, if ICT-developers are to be held accountable to make ICT universally usable. After all, not only ICT-developers suffer from age stereotypes. Staufer (1992) found in interviews with white collar workers in German companies, that age stereotypes are common and accepted by older workers themselves. Even if older adults knew as much as younger adults about IT,

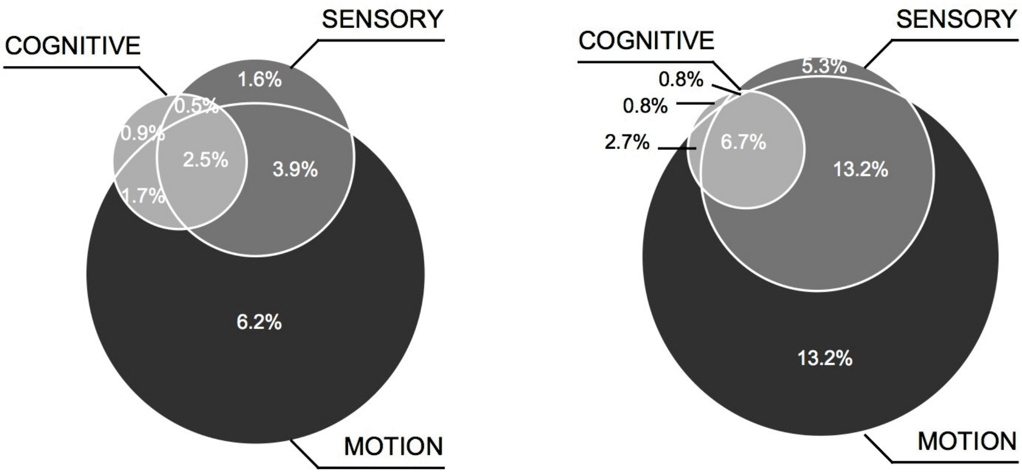

Figure 7. Prevalence of multiple capability losses for people aged 16+ (left) and 65+ (right). Figure taken from Dong et al. (2003, p.8)

they felt „less knowledgable" (Marquie et al., 2002) and older workers (aged 55+) believed significantly more often than younger colleagues that they themselves were to blame for computer trouble (Gertler et al., 1999).

Age differences. Undeniably, besides the motivational differences following functional adaptation described above (SOC), there are also age related changes in cognitive abilities that have an impact on the ability to interact with ICT (Schaie, 1996; Schaie & Willis, 2010). Czaja (1996) provides an overview of such changes, mainly addressing slower processing speed, decline in working memory and less efficient encoding and their impact on computer training and interface design. More detailed information on changes regarding executive function, structural changes to the brain, neuroplasticity and memory etc. can be found in Schaie & Willis (2010).

When designing for older adults, one should be careful not to equate aging with disbility: Not all older adults have disabilities and not all disabled people are old. In fact, one in six adults has a disability, with numbers increasing with age and minor losses can have a cumulative effect, that is they can combine to limit capabilities as much as more severe impairments (Keates, 2007, p.19). Figure 7 shows the prevalence of multiple capability losses for people aged 16+ (left) and 65+ (right) in a Venn diagram.

Cognitive resources can be conceptualized as functional capacity created by the interaction between cognitive-processing efficiency and task-relevant knowledge (Hertzog et al., 2009; Ericsson & Kintsch, 1995). While it is the goal of individuals of all ages to maintain functional capacity over the life course, this becomes increasingly challenging with high age. Figure 8 (left) shows the zone of possible cognitive development across adult life for a given individual. The gray area indicates the range of possible cognitive function, with the arrows pointing to the upper and lower boundaries that define the range at any given age (plasticity) and the dots between them indicating the actual development. Up and down movements are influenced by biological, behavioral, and environmental factors and the functional threshold

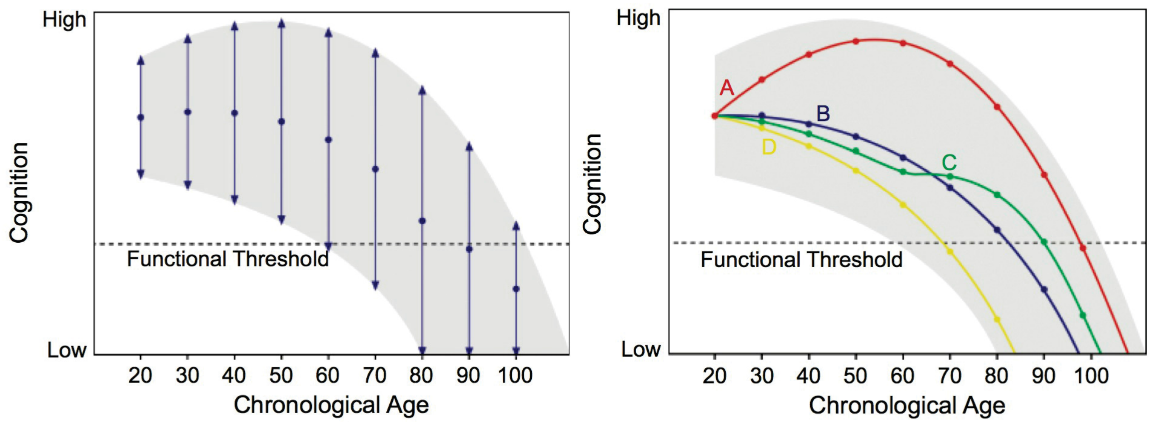

Figure 8. Zone of possible cognitive development across adult life for a given individual (left), along with four developmental curves (A - D) indicating specific possible outcomes (right). Figures taken from Hertzog et al. (2009, p. 5 and 8)

indicates a point at which goal-directed cognition in the ecology (e.g. necessary for independent living or for use of a specific technology) will be compromised (Hertzog et al., 2009, p. 5). This threshold is not fixed but depends in turn on the requirements (e.g. for independent living or technology use), that we co-create in our social and physical environment.

Figure 8 (right) shows four developmental curves (A - D) starting from the same functional level at age 20, indicating specific possible developmental trajectories (Hertzog et al., 2009, p. 8). Biological aging will reduce the maximum achievable level of performance because it leads to less effective or efficient execution of cognitive, perceptual, and sensory aspects of information processing in the brain (Hertzog et al., 2009; Schaie & Willis, 2010), yet the individual has some control over the actual developmental trajectory. Stine-Morrow (2007, p. 296) illustrates this in her "Dumbledore hypothesis of cognitive aging" with the Hogwarts headmaster Albus Dumbledore reminding Harry Potter that "It is our choices . . . that show what we truly are, far more than our abilities" (Rowling, 1999, p. 333), arguing that it is "our pattern of choice to engage intellectual challenge that contributes to cognitive vitality, far more than the senescence process." Curve C in figure 8 could illustrate the "cognitive enrichment effect" of such an intellectually challenging intervention around age 60 (Hertzog et al., 2009, p. 8). As Hertzog et al. (2009, p. 1)emphasize: "Individuals influence whether they function in the higher or lower ranges of this zone by engaging in or refraining from beneficial intellectual, physical, and social activities".

Technology use can be an important source of cognitive enrichment for older adults, (a) directly through challenging interaction with the technology itself (either as an inevitable byproduct e.g. with smart phones or TVM use or desirable in itself as in computer-based cognitive training programs (e.g. Schmiedek et al., 2010) and games for seniors (Jung et al., 2009; Nap et al., 2009; Whitcomb & Whitcomb, 1990)) and (b) indirectly by extending the scope of possible actions that improve social participation and activity in general (e.g. by providing access to information through the Internet and to mobility services through public transportation / TVM).

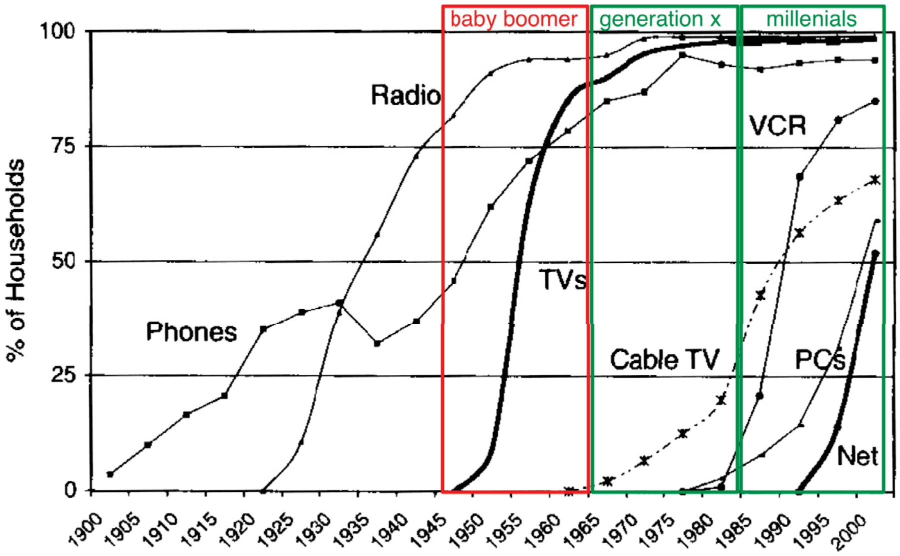

Figure 9. Twentieth-Century technology in the USA with generational birth cohorts of baby boomers, generation X and millenials (generation Y). Figure based on Norris (2003, p. 33)

Cohort differences. Since most older users of public transportation TVMs and other public access systems are still independent and healthy adults well above the functional threshold, for this user group, other factors related to age require particular interest, so called generational cohort factors. Ryder (1965, p. 845) defined a cohort "as the aggregate of individuals (within some population definition) who experienced the same event within the same interval". While this can be any event, most often this event is birth, resulting in a “birth cohort”. "Successive cohorts are differentiated by changing content of formal education, by peer-group socialization, and by idiosyncratic historical experience" Ryder (1965, p. 843). If the interval spans a whole generation, the term “generational cohort” is used.

The term generation generally refers to one reproductive cycle, spanning the age difference between parents and their children. While this was typically estimated to be 30 years, on average, age differences between fathers and their children are bigger than for mothers. In 1923, Karl Mannheim argued for social generations as cohorts of people who were born in the same date range and share similar cultural experiences (Mannheim, 1923; Pilcher, 1994). Today, this concept of social generations has become part of popular culture. The older adults of interest in this thesis are aged 60 years or older and often categorized as the “baby boomer” generation. The baby boomers were born right after World War II, between the years 1946 and 1964, and began turning 60 in 2006. By 2029, all baby boomers will be 65 years and over, constituting more than 20 percent of the total U.S. population (Colby & Ortman, 2014).

For the baby boomer generation, generational cohort differences may have a bigger impact on their ability to use ICT (and the TVM in particular) than age differences, for they grew up prior to widespread use of computers. The first computationally universal computer, called Zuse Z3, was built in 1941 by Konrad Zuse in Berlin, but most people did not use computers on a regular basis before the introduction of personal computers. Two events further popularized ICT use: (1) The introduction of the graphical user interface (GUI) in the Xerox Alto in 1973 that inspired the first mass-market personal computer featuring an integral graphical user interface and mouse, the Apple Macintosh in 1984 and the graphical interface operating system called Windows, released by Microsoft in 1985 and (2) The invention of the WWW by Tim Berners-Lee (CERN) in 1989 and the addition of a graphical browser called Mosaic in 1993 (Norris, 2003). Figure 9 shows the baby boomer generation birth cohort and the following generations X and Y superimposed on a graph visualizing the prevalence of common technology in the United States in the 20th century (Norris, 2003, p. 33). It reveals that baby boomers were born in the age of telephone, radio and TV, and only after the last baby boomers had reached their 20s, personal computers slowly became more popular.

Compared to later generations, the baby boomers had less opportunity to interact with computers and acquire interaction knowledge or "computer literacy" when they were young - and they still make less use of ICT today. In the year 2000, 3950 people from five European countries (Finland, Germany, Hungary, Italy, Netherlands) aged 55 and over were asked about their use of new technology in the Mobilate survey. 66% reported to use an ATM, which was the highest number, followed by 37% for the ticket vending machine (TVM), 32% for the mobile phone, 8% for Internet and 4% for Telebanking (Tacken et al., 2005). Zickuhr & Madden (2012, p. 2) report data based on telephone interviews in the United States (N = 2254 adults, age 18 and older), showing that as of April 2012 „for the first time, half of adults ages 65 and older are online“. While this marks a promising 10% gain compared to data of April 2011, younger cohorts have reached far higher values, namely 77% for those aged 50-64, 91% for those aged 30-49 and 97% for those aged 18-29.

Selwyn et al. (2003) report results from a sub-sample of 352 adults aged 60+ years taken from a large (N=1001) household survey of ICT use in England and Wales, including Level of access to computers by social and health characteristics and frequency of computer and Internet use in the last 12 months. They conclude that „Older adults' computer use mainly takes place at home, and where support is available it is mainly from the immediate household and relatives“ and point out that „Having access to ICT is not however the same as using it.“ - While 83% of the sample had some access to computers, only 22% reported having used a computer during the previous 12 months (Selwyn et al., 2003, p. 572). In a study by Mitzner et al. (2010), 18 focus groups with a total of 113 older adults discussed their use of and attitudes about technology in the context of their home, work, and healthcare. The mean number of technology items reported in each focus group and the most frequent technologies discussed in each domain were: for home (19 items) = computer (13%), microwave (12%), cellular phone (11%), for work (13 items) = computer (19%), fax (14%), telephone (13%) and for health (7 items) = blood glucose monitor (17%), blood pressure monitor (16%), telephone (15%). Overall, positive attitudes (most likes for "support for activities") outnumbered negative attitudes (most dislikes for "inconveniences" = "making life harder in some way") and „results contradict stereotypes that older adults are afraid or unwilling to use technology“ (Mitzner et al., 2010, p. 1710).

Age related user characteristics chosen as control variables. As Rogers & Fisk (2010) point out: "Chronological age may be predictive of usage patterns, difficulties, or preferences, but it is not an explanatory variable—it does not explain why the differences occur." There are a variety of age related user characteristics expected to have an impact on ICT use from the literature (e.g. Czaja et al., 2006; Charness, 2009; Fisk et al., 2009) and prior studies within the ALISA project (e.g. Butenhof, 2006; Struve et al., 2006; Sengpiel et al., 2008) and six were selected as control variables in the studies reported in this thesis to see if they can explain age differences found in usability criteria for TVM interaction better than chronological age itself.

Two of them measure aspects of fluid intelligence known to be effected by biological aging: the Digit Symbol-Coding task of the Wechsler Adult Intelligence Scale (WAIS DSC, Wechsler, 1955) measuring information processing speed and attention, and the subscale "reasoning" of the "performance test system 50+" (German: "Leistungsprüfsystem 50+" = LPS 50+, Horn, 1983). Even though it is not directly related to TVM or computer use, intelligence has an impact on its (successful) use as it has on problem solving as a "general factor". As Czaja et al. (2006) have shown, there is a strong relationship between fluid and crystallized intelligence (β=.89) and between age and fluid (β=-.66) and crystallized (β=.76) intelligence, yet fluid intelligence has a far stronger impact on the use of technology (β=.32) than crystallized intelligence. The other four control variables are directly related to computer use and cohort effects, measuring control beliefs in the interaction with technology (KUT, Beier, 1999), computer anxiety (CATS, Gaudron & Vignoli, 2002), attitude towards ticket vending machines (ATT) and computer literacy (CLS, Sengpiel & Dittberner, 2008). They will be described briefly in the method section, with a special focus on computer literacy because it was expected to be the best predictor of TVM use.

Research questions and study overview

Fortunately, there is a large body of research available to aid in the development of universally usable products, especially with a focus on older adults. Rogers & Fisk (2010) provide an overview of psychological research on ICT design for older adults, identifying three facets: 1) usability issues with current technologies like input devices, computers, Internet, mobile phones, ATMs etc. 2) adequacy of training and instruction materials and 3) understanding the needs and requirements of older adults as foundation for improvement and development of new technologies. Acknowledging that „The literature on the psychology of aging provides much guidance for design—the challenge is in the translation." (Rogers & Fisk, 2010, p. 646), they provide such a translation with a comprehensive selection of research and guidelines for system designers in their book „Designing for older adults" (Fisk et al., 2009).

This thesis uses such translations to answer four related research questions:

1. To what degree is successful TVM use determined by age related user characteristics rather than by age itself? This seems important, because chronological age cannot be changed, but age related user characteristics can be accomodated through good design and knowing which characteristics have a bigger impact might help with design decisions. This leads to the second question.

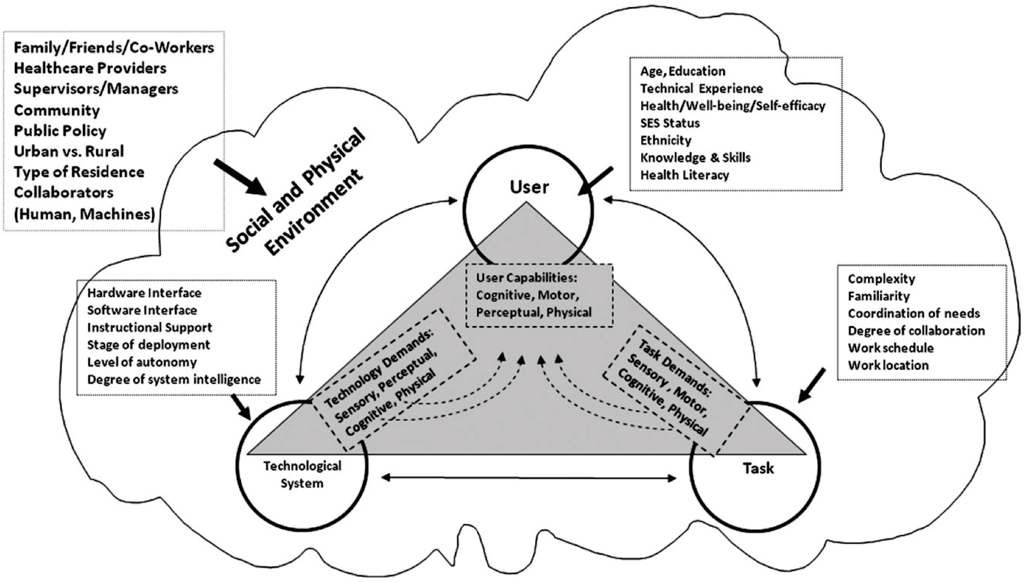

Figure 10. CREATE model of aging and technology. Figure taken from Rogers & Fisk (2010, p. 647)

2. Is computer literacy an important predictor of successful use, even with a relatively simple ticket vending machine? These two questions are the focus of the article “Too old to use IT? User characteristics and the effectiveness of inclusive design” (Sengpiel, in pressb).

3. How can the usability of a given TVM be improved so that it becomes universally usable for older adults? Given the importance of computer literacy for successful TVM interaction, in principle, designers have two choices: they can teach the user the necessary interaction knowledge, or they can design the machine to require less computer literacy for successful use, bringing it closer to the goal of universal usability.

4. How can both design choices, teach and design, be compared regarding cost and benefit for the example of a TVM? Is the required cost reasonable given the benefits to be achieved? This question seems very relevant for the propagation of universal usability efforts, in particular if small changes prove to have a substantial effect on usability for older adults. Questions three and four are the focus of the article “Teach or design? How older adults’ use of ticket vending machines could be more effective" (Sengpiel, in pressa). The third article "Compensating the effects of age differences in computer literacy on the use of ticket vending machines through minimal video instruction" (Sengpiel & Wandke, 2010) compares only video instruction and original BVG TVM (N=83), yet focuses already on the effect of computer literacy on successful TVM use, paving the way for the other two articles.

To answer these questions, the studies described in this thesis follows a quasi experimental research design (Schaie, 1977), focusing on successful use of a TVM by older adults. Starting from the CREATE model of aging and technology (see Fig. 10) they concentrate on the cognitive demands of the technological system and compare three TVM designs (Original BVG, Video, Wizard) regarding the usability criteria effectiveness, efficiency and satisfac-

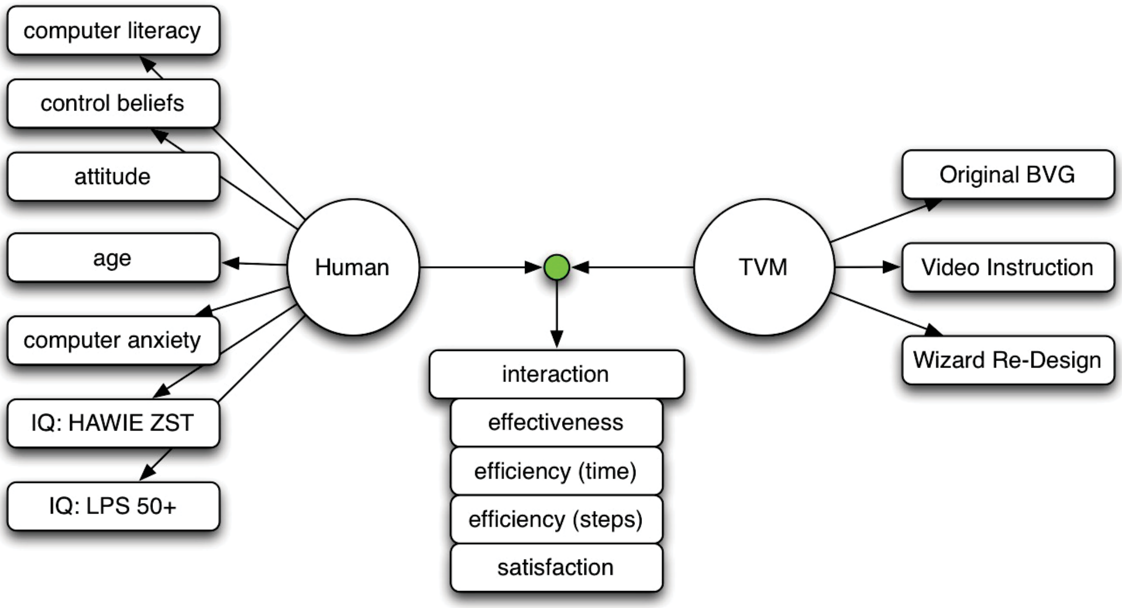

Figure 11. Study overview

tion according to EN ISO 9241-11 (1998). Age as well as six cognitive and motivational user characteristics relevant for technology use have been measured as control variables, while task and environmental characteristics were held constant. Figure 11 provides an overview of the studies[8].

[8]Note that in this study task and environment (see Fig. 10 & 2) were held constant for the comparison.

Table 1: Number of participants in the age and experimental groups

N	young	old	sum
control	20	18	38
video	21	19	40
wizard	20	20	40
sum	61	57	118

Figure 12. Screenshots of the simulated ticket vending machine

Method

Research design and procedure

Participants were recruited in two age groups with a total of n=62 older adults (M=68.2 years, SD=4.8, 35 female, 27 male) and n=62 younger adults (M=24.5 years, SD=4.14, 29 female, 33 male). Participants from the two age groups were evenly assigned to the three experimental conditions with a target group size of 20, resulting in a two (age-group: young / old) by three (experimental condition: control, video, wizard) factorial design. Figure 11 provides an overview of the studies. Six of the participants produced incomplete data sets (missing data mostly due to unfinished tasks) and were excluded from the MANOVA as main statistical analysis resulting in group sizes shown in Table 1.

Participants in the control condition used a simulated TVM of the BVG (Berlin Public Transportation) to solve eleven tasks in which they had to select tickets for purchase. The TVM was built in Squeak/Smalltalk (see A. Black et al. (2009) for an introduction) and presented on a 19" touch screen monitor to resemble the original as close as possible (see Fig. 12).

The eleven tasks described one or more tickets to be selected with the TVM (e.g. „Please purchase a single ticket for Berlin ABC, reduced fare“, see a complete list of tasks in Table E4) and ended by pressing a "purchase now" button that was added to replace the actual payment process. All tasks were realistic and solvable. They were presented in fixed order and varied in difficulty, beginning easy for motivational reasons. The test session began with a practice task (task 0) that was not used to measure results. The investigator

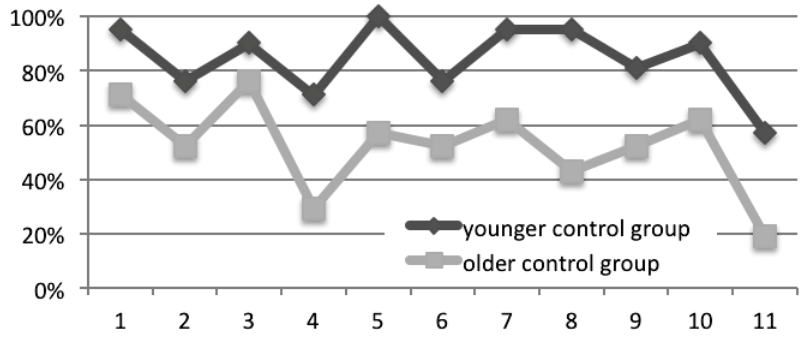

Figure 13. Frequencies of correctly solved tasks for the younger and older control group

Figure 14. Screenshots of the minimal video instruction

provided the necessary domain knowledge (e.g. "What does Berlin ABC mean?") in the instruction before the tasks and the tasks explicitly named the required tickets. A task counted as correctly solved only if exactly the required tickets were chosen. On average, the younger group solved 84% and the older group 52% of them correctly. Fig. 13 shows the frequency of correctly solved tasks in the order they were presented. The whole experiment lasted about 60-90 minutes, with the fixed task section embedded in questionnaires and interviews. Participants received 10€ compensation.

Minimal video instruction

In the video condition, participants used the same simulated TVM as in the control condition. However, immediately before solving the same eleven tasks, participants saw a short (2:37 min) instructional video, in which a narrators voice provided basic interaction knowledge for the use of the ticket vending machine and pointed with his finger on the graphical user interface (GUI). In the video, all ticket button descriptions had been removed from the GUI to avoid teaching domain knowledge along with the interaction knowledge. The video instructed on six main points:

1. Yellow buttons can be pushed and turn green when activated, grayed out buttons are currently disabled.

2. The white bar on the right contains a button to go one step back and one to start over (red).

Figure 15. Prototypes (above) and screenshots (below) of the wizard-GUI of the TVM

3. If there are more buttons than fit on the screen at once, arrow buttons appear that toggle to the others (even though they appear to be „scrolling buttons", their function is rather to turn the page).

4. There is a shopping cart function („Warenkorb") that shows the tickets already selected.[9]

5. To remove tickets from the shopping cart, one needs to press the x-button on the right.

6. At the end there is a pay now („Jetzt bezahlen") button that replaces the payment process found in the real TVM (this button was the only one in the video bearing a description)

The video finished with the same image it had started with so it could be looped. Participants were instructed to touch the screen to stop the video and start with the tasks when they saw fit. The video was scripted and filmed at the Computer and Media Service of Humboldt-University Berlin with the aid of Laura Felten (diploma thesis) and Jörg Schulze (video expert). Figure 14 shows screenshots from the video instruction, the whole video can be found on the CD accompanying this thesis.

Wizard redesign

In the wizard condition, participants received no video instruction and solved the same tasks using a different Graphical User Interface (GUI) that had been designed applying general and inclusive design principles (Carroll, 1997; Rosson & Carroll, 2002; Fisk et al., 2009; Dreyfuss, 2003, 1955) to require less computer literacy for successful use. For that purpose, the user's task of purchasing a ticket was analyzed and taken as basis for a wizard design that

[9]This function was hard to understand for people with little Internet experience and designers might be well advised to reconsider its use or explain it better

Table 2: reliability of dependent variables

dependent variable	# of items	N	Cronbach's Alpha
effectiveness	11	124	.747
eff (time)	11	124	.911
eff (steps)	11	124	.785
satisfaction (QUIS)	13	118	.952

guides the user through the ticket selection process. The wizard does not anthropomorphize the machine, but rather refers to a design pattern that guides the user through a complex task by decomposing it into a set of manageable steps (Folmer & Bosch, 2003). Since people generally know how to purchase a ticket (e.g. at the ticket counter), a second guideline in the wizard GUI-design was to decompose the ticket selection process into four manageable steps following main questions from the user's perspective: **Who** wants to go? **Where** is the destination? **How long** should the ticket last? **How many** tickets are needed? These steps were present at the top of the screen at all times, providing orientation and quick navigation for easy error recovery. Third, goal oriented status feedback was provided in the shape of an actual ticket filling up with the choices made, so users could see immediately the effect of their actions, directly on the desired object. Finally, interaction principles and symbols that might be unknown to older users were avoided as much as possible without compromising functionality.

After the wizard had been designed as a paper and pencil prototype (Hackos & Redish, 1998) and further visualized using OmniGraffle (see Fig. 15 and section B on page 97 in the appendix) it was programmed as a new user interface for the same TVM simulation used in the control and video groups in Squeak/Smalltalk and presented on the same 19" touch screen monitor. Thus, the wizard was built to be functionally equivalent to the original TVM and differed only in the GUI. Figure 15 shows screenshots of the wizard GUI for the TVM simulation. Both, the simulation of the Original BVG TVM and the Wizard have been used again in other studies, e.g. by Hurtienne et al. (2013).

Usability measures as dependent variables

To measure the impact of the video and wizard interventions, the usability criteria effectiveness, efficiency and satisfaction (EN ISO 9241-11(1998), Dzida, 2001, Bevan & Macleod, 1994) of the interaction were used. To be able to compare all dependent variables across tasks and experimental conditions, they were transformed to percent with efficiency based on the same overall minimum of necessary steps and times. Since the eleven tasks can be seen as a scale measuring the latent variable, their reliability was calculated along with the reliability of the satisfaction scale. Table 2 shows the resulting reliability values that range between acceptable and excellent (Field, 2009, p. 709ff).

Effectiveness. A task was considered correctly solved only if exactly the described tickets were chosen and the button „buy now“ (German: "Jetzt bezahlen") was pushed, which had been added to the TVM-simulation to replace the actual payment process. Effectiveness

Table 3: Minimum number of necessary steps to solve the eleven tasks

Task	1	2	3	4	5	6	7	8	9	10	11	Total	Mean
Original	3	9	7	13	13	11	8	14	9	6	8	101	9.2
Wizard	9	9	13	16	14	17	8	23	14	10	13	146	13.3

was measured as the number of correctly solved tasks ($tasks_{solved}$) divided by the number of tasks ($tasks_{total}$). Thus, an effectiveness of 50% means that participants had correctly solved half of the tasks.

$$Effectiveness = \frac{tasks_{solved}}{tasks_{total}} * 100\%$$

Satisfaction. Satisfaction was measured as the mean score of 13 items based on the Questionnaire for User Interface Satisfaction (QUIS) by Chin, Diehl, & Norman (1988). QUIS reliably (Cronbach's alpha=.94) "measures the user's subjective rating of the human-computer interface" (Chin et al., 1988, p.213). It was shortened and adapted to TVM use, asking users to rate their satisfaction on a nine point bipolar scale (semantic differential) in five applicable fields: general impression (three items), on screen presentation (three items), logical sequence (three items), choice of words (two items) and feedback (two items). Sengpiel (in pressa, p. 9) shows the items translated from the German version used in the studies.

Efficiency. Efficiency was measured separately with the number of steps (button clicks[10]) and the time it took to solve a task (not including the time to watch the video). This differentiation was made because interventions were expected to influence both measures differently. Efficiency measured in steps was measured as the minimum number of steps necessary to solve the task (steps$_{necessary}$) divided by the number of steps actually needed by the user to solve the task (steps$_{needed}$) and multiplied with effectiveness, which could be only 1 (correctly solved) or 0 (not correctly solved) for any given task. Efficiency measured in time was measured the same way, yet while the number of necessary interaction steps could be counted from the ideal solution path, the necessary time was predicted as the task execution time of a skilled user with CogTool modeling. This process is described in Sengpiel (in pressa, p. 8). Thus, an E(steps) and E(time) of 50% means that participants had needed twice the number of steps and twice the time necessary to correctly solve the tasks.

$$Efficiency_{steps} = Effectiveness * \frac{steps_{necessary}}{steps_{needed}} * 100\%$$

$$Efficiency_{time} = Effectiveness * \frac{time_{necessary}}{time_{needed}} * 100\%$$

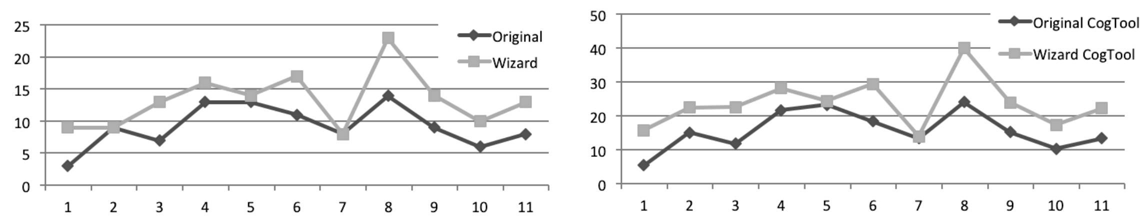

Figure 16. Minimum number of necessary steps (left) and CogTool-estimated skilled user times (right) to solve the eleven tasks in seconds, providing the baseline for efficiency measured in steps and time

Table 4: CogTool-estimated skilled user time estimates to solve the eleven tasks in seconds

Task	1	2	3	4	5	6	7	8	9	10	11	Total	Mean
Original CogTool	5	15	12	22	23	18	13	24	15	10	13	172	16
Wizard CogTool	16	22	23	28	24	29	14	40	24	17	22	260	24

Predicting task execution time for skilled users of the UI using CogTool modeling

To provide a baseline for measuring time-efficiency, CogTool (John, Prevas, Salvucci, & Koedinger, 2004) was used to estimate how much time a skilled user would need to solve the eleven tasks using the original TVM and the wizard redesign. "CogTool uses a 'cognitive architecture' called ACT-R ... to simulate the cognitive, perceptual and motor behavior of humans interacting with the prototype to accomplish tasks the UI designer has defined. CogTool ... reliably predicts the task execution time for skilled users of the UI" (John, 2009, p.2).

Figure 16 shows the number of necessary steps and skilled user times providing the baseline for efficiency measures (see also table 3 and 4). Evidently, the original TVM requires less steps for almost all tasks (M=9.2 for the original TVM and M=13.3 for the wizard), with notable exceptions for task 2, 5 and 7. As expected, the times predicited by CogTool follow the pattern of necessary steps. They range from five seconds for task 1 with the Original TVM to 40 seconds for task 8 with the Wizard, with a mean of 16 seconds for the original and 24 seconds for the wizard. Figure 17 shows screenshots from the CogTool - software for the Original BVG GUI covering the tasks 1 - 4 and figure 18 shows the same for the Wizard GUI covering the tasks 1-3. Arrows mark transitions from screen to screen. Figure 19 shows CogTool results comparing task five for the original BVG and the wizard GUI.

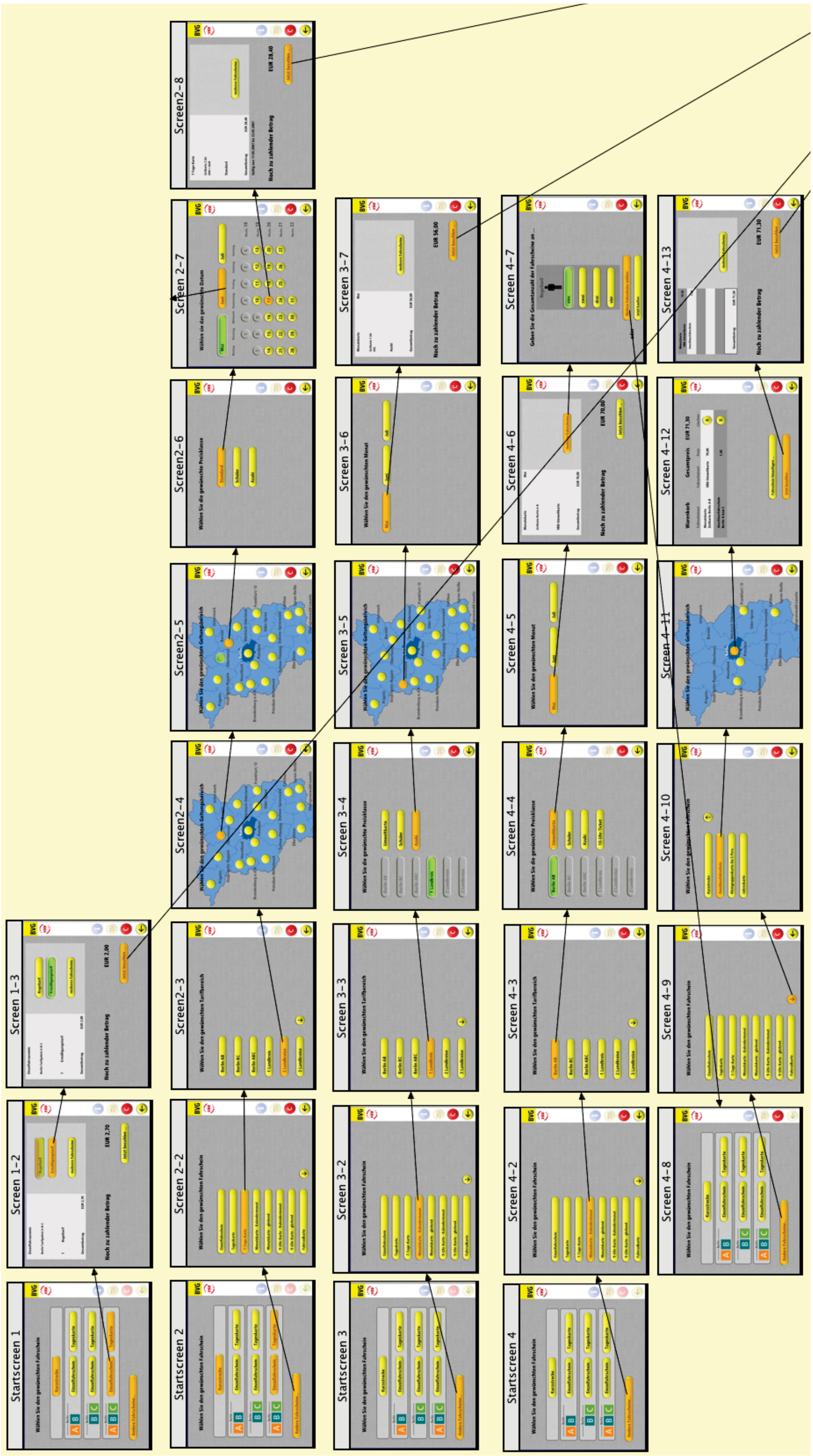

Figure 17. CogTool screenshots for the Original BVG GUI covering the tasks 1 - 4. Arrows mark transitions from screen to screen.

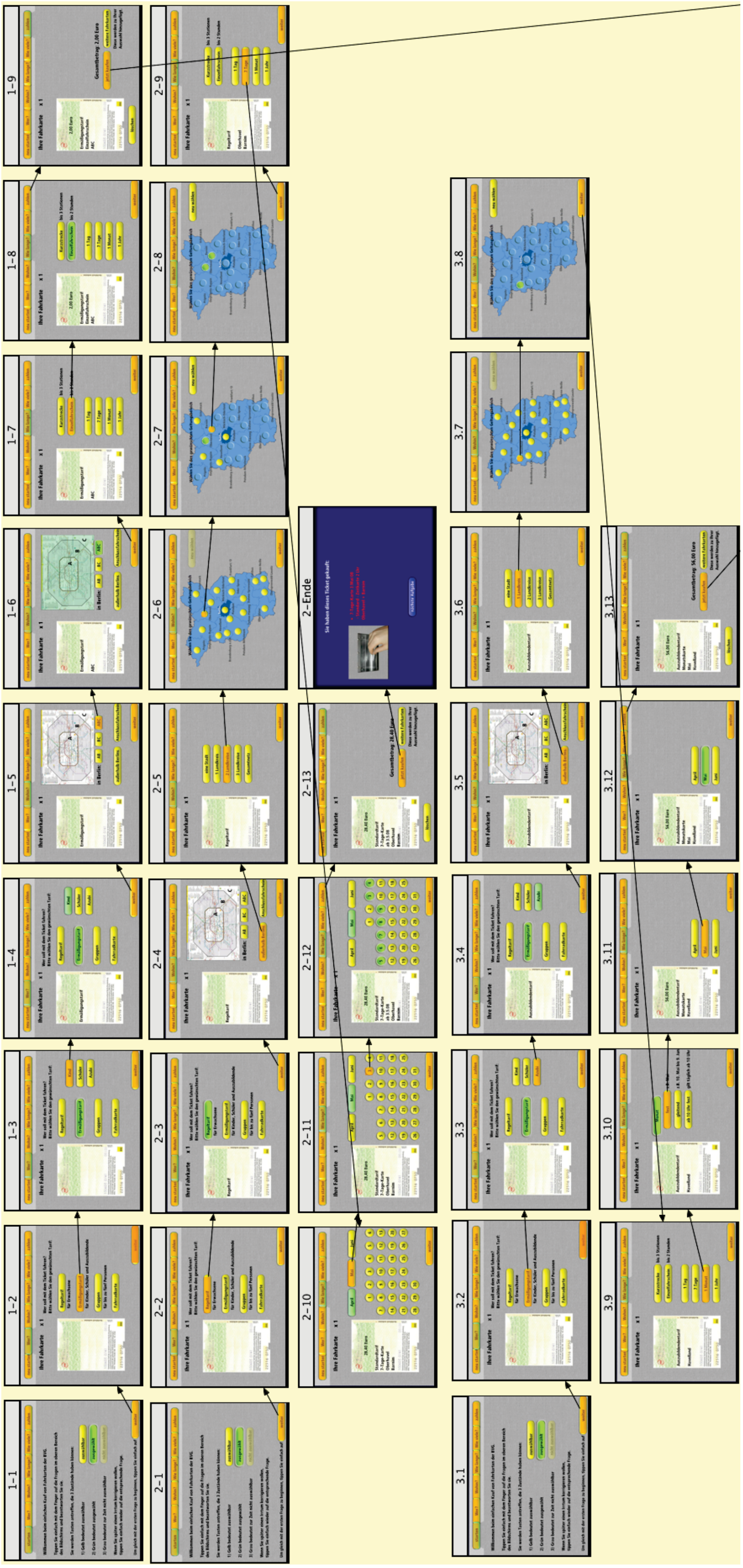

Figure 18. CogTool screenshots for the Wizard GUI covering the tasks 1-3 (right). Arrows mark transitions from screen to screen.

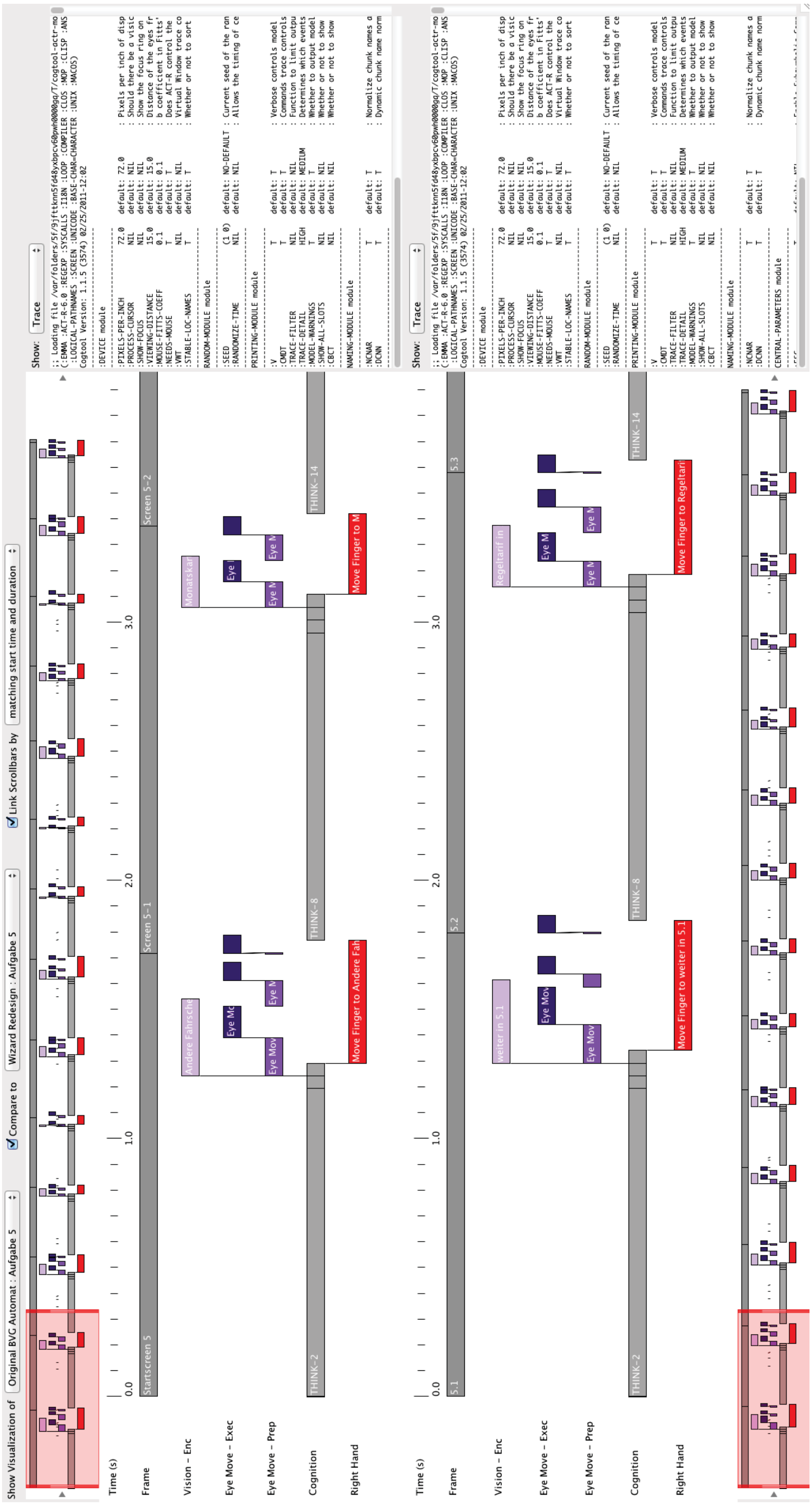

Figure 19. CogTool results, example comparing task five for the original BVG and the wizard GUI

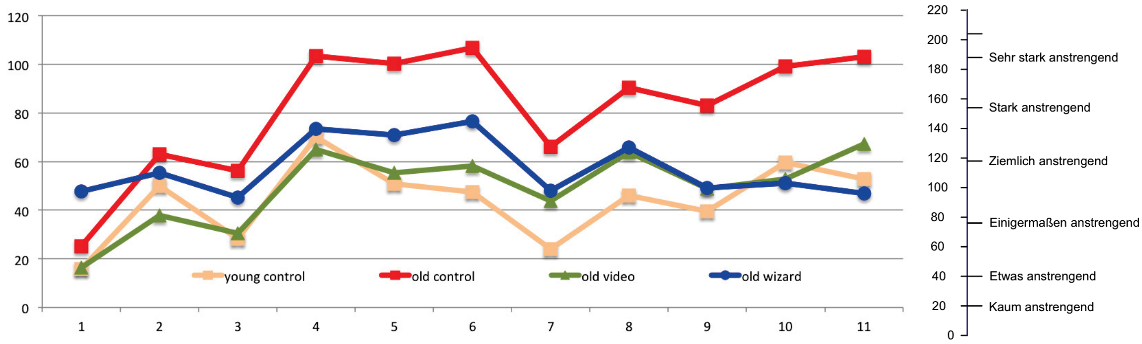

Figure 20. Group means of Rating Scale Mental Effort (RSME) across the eleven tasks. Note that the scale is cut off at 120 because all tasks were less than "rather taxing", see the adapted German rating scale used in the study on the right.

Rating Scale Mental Effort (RSME)

Mental workload is an important measure in the research and development of HCI and ergonomics (Rubio et al., 2004). Mental workload was measured using the Rating Scale Mental Effort (RSME) by Zijlstra and van Doorn (1985), but results were not reported in the research articles due to space constraints. There are a variety of measures available for mental workload - among them, NASA-TLX (Task-Load Index) and SWAT (Subjective Workload Assessment Technique) are frequently used (Rubio et al., 2004). The NASA-TLX (Task-Load Index) by Hart & Staveland (1988) is often used in multitask contexts, i.e. flight tasks in air combat. It uses six dimensions to assess mental workload: mental demand, physical demand, temporal demand, performance, effort, and frustration and takes about 60 min to complete. The SWAT (Subjective Workload Assessment Technique) by Reid & Nygren (1988) is a subjective rating technique that uses three levels: (1) low, (2) medium, and (3) high, for each of three dimensions of time load, mental effort load, and psychological stress load to assess workload and takes about 70 min to complete. Both of these measures (and most others) required too much time to be included in our TVM studies. Instead, a very brief measure was chosen that yields surprisingly high correlations (Rubio et al., 2004, p. 73) with NASA-TLX (0.653, $p<.01$), but not with SWAT (0.292, $p<.05$): The RSME (Rating Scale Mental Effort) by Zijlstra and van Doorn (1985).

The RSME is a one item scale on which participants were to mark the mental workload they had experienced during the task on the scale immidiately after every single task and once during the interview in the beginning to provide a baseline. The German adaptation of the RSME (Zijlstra & Doorn, 1985; Zijlstra, 1993) that was used ranged from 0 to 220 using german anchor terms (e.g. 120 = "Ziemlich anstrengend" for "Rather taxing") and participants mean RSME baseline across all groups was 9 (to compare: 20 = "kaum anstrengend" for "hardly taxing").

To estimate the relationship between subjective mental workload (RSME) and the

[10] Button clicks were counted as steps, because the TVM features simple push buttons and no complex interaction elements such as spin buttons or sliders.

Table 5: Pairwise comparisons (Bonferroni corrected) of RSME scores for old control group (I) and other experimental groups (J)

experimental group	N	mean RSME	I-J	SE	Sig.
old control	21	81.47			
young control	21	38.66	42.81	8.599	.000
young video	21	39.79	41.68	8.599	.000
old video	18	44.05	37.42	8.950	.013
young wizard	19	50.78	30.69	8.823	.000
old wizard	20	57.20	24.27	8.706	.093

dependent variables effectiveness, efficiency and satisfaction, Pearson correlations were calculated and supplemented with Bootstrap 95% confidence intervals based on 1000 replications. Table 6 shows the correlations in three groups: First, overall correlations are reported, then the sample is split into young and old and finally into the six experimental groups. To improve readability, nonsignificant correlations have been removed from the table. The complete table can be found in the appendix (Table E15).

Older adults using the original BVG-TVM (old control) reported significantly higher subjective mental workload (RSME score) across the eleven tasks than all other groups, including old video and old wizard, who had slightly but not significantly higher RSME-scores than the younger groups (see figure 20).

In a factorial repeated measures ANOVA with the eleven tasks as repeated measures and experimental groups as factors, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(54) = 208.47$, p=.000. Thus, Greenhouse-Geisser corrected tests are reported ($\varepsilon = .74$). The results show that mental effort (measured as RSME score) was significantly affected by the task (F(7.40, 843.28) = 32.61, p = .000, $\eta_p^2 = .222$ and the interaction of task and experimental group (F(36.99, 843.28) = 2.66, p = .000, $\eta_p^2 = .105$. Pairwise comparisons between experimental groups reveal significant differences between the old control group and all other groups (see table 5), creating two homogenous subgroups (Ryan-Einot-Gabriel-Welsch, Sig. = .225).

Overall, subjective mental workload was correlated with all dependent variables, yet strongest with satisfaction. Participants who reported less mental effort when using the TVM were also more satisfied, effective and efficient using it. Comparing young and old participants, this effect persists for satisfaction (highest) and effectiveness, and is stronger for younger adults, which could indicate that older adults were less willing to expend increased effort on difficult tasks or less able to compensate usability flaws in the TVM. For efficiency, only one significant correlation remains: older adults perceiving higher mental effort took more time to solve the tasks. Comparing all six experimental conditions, the highest correlations exist between mental effort and satisfaction in the young video (-.721**) and young wizard group (-.706**), followed by the old control (-.614**) and the old wizard group (-.613**).

To summarize, RSME had a stronger connection to satisfaction than to effectiveness, even though task difficulty is operationalized as frequency of correct solutions (= effectiveness). Task difficulty and mental effort were not as strongly correlated as expected - The

Table 6: Pearson correlations of mental effort (RSME mean scores) and effectiveness, efficiency and satisfaction (dependent variables) for all experimental groups, nonsignificant results removed to improve readability

group	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
overall	-.387**	-.364**	-.309**	-.514**
	(-.58, -.16)	(-.51, -.22)	(-.47, -.12)	(-.68, -.31)
young	-.362**			-.594**
	(-.53, -.09)			(-.75, -.39)
old	-.291*	-.352**		-.461**
	(-.54, .03)	(-.54, -.15)		(-.69, -.17)
young control	-.641**		-.490*	
	(-.86, -.13)		(-.75, .07)	
old control				-.614**
				(-.88, -.25)
young video				-.721**
				(-.90, -.29)
old video				
young wizard		-.466*	-.496*	-.706**
		(-.73, -.12)	(-.71, -.23)	(-.86, -.54)
old wizard		-.554*		-.613**
		(-.80, -.12)		(-.88, -.22)

N=118, *p<.05, **p<.01 (2-sided), Bootstrap (1000) 95% CIs reported in brackets

relationship may be affected by achievement motivation (Capa et al., 2008). Another caveat is that self-report scales alone cannot capture mental workload (Waard & Lewis-Evans, 2014).

Control Variables

User characteristics besides age, that were expected to influence effectiveness, efficiency and satisfaction of TVM use include prior computer experience and the resulting computer literacy, computer anxiety, attitude and control beliefs regarding technology use. As a general factor, fluid intelligence was measured as well. These control variables are introduced briefly, a more detailed description along with results of a hierarchical regression indicating their relative importance as predictors of usability measures can be found in Sengpiel (in pressb). Overall, there were significant differences between between age groups, but not between control, video and wizard conditions (see Fig. 21 for an overview).

KUT. The KUT (German akronym for "control beliefs for interaction with technology") was developed by Beier (1999) to extend the scope of observed user characteristics with a personality construct that guides user actions. The short eight item scale was adapted to

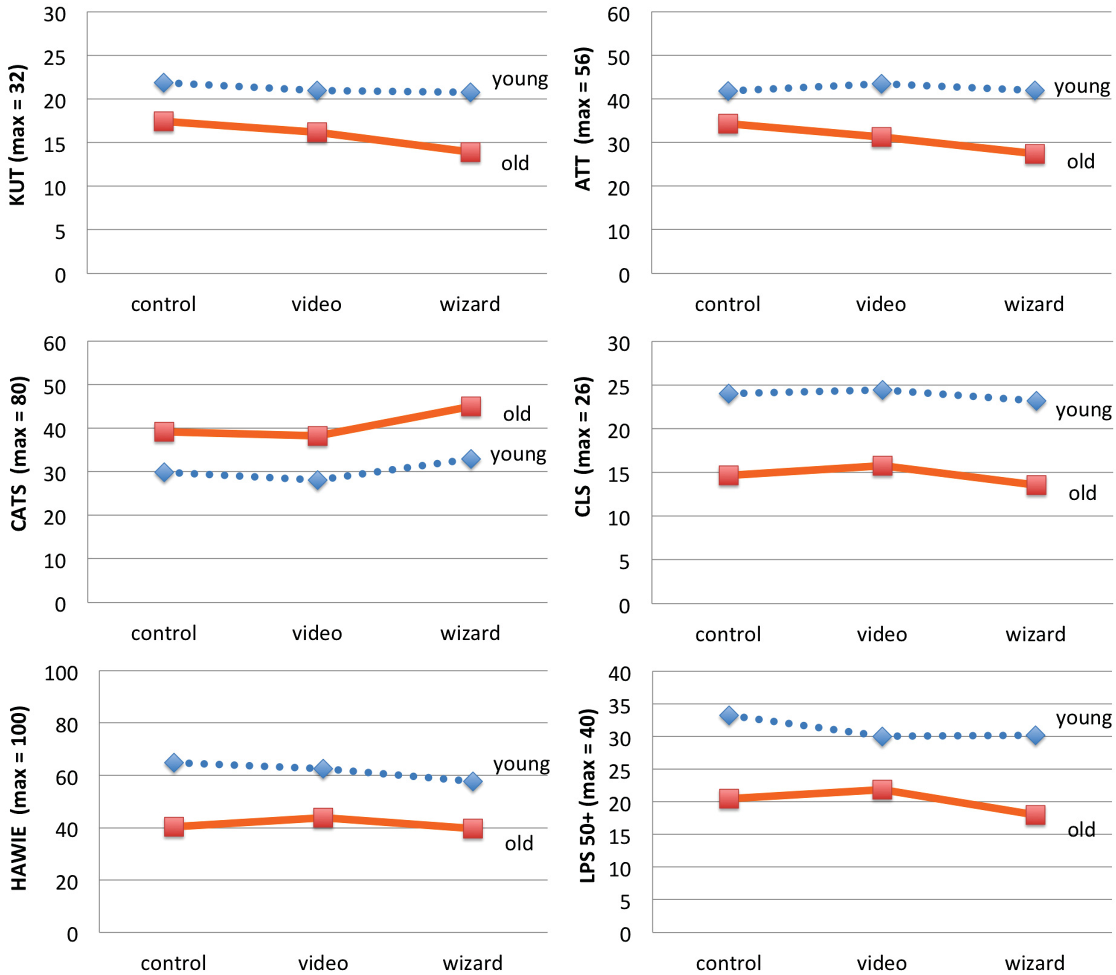

Figure 21. KUT, ATT, CATS, CLS, HAWIE (=WAIS) and LPS 50+ scores in the control, video and wizard conditions, split for old and young participant groups

TVM use by adding the example „purchasing train tickets at a ticket vending machine“ and participants indicated on a Likert scale of 0 (not true at all) to 4 (absolutely true) their control beliefs regarding technology use, resulting in a maximum total score of (8x4=) 32. A complete list of translated items, including polarity, mean, variance and discriminatory power from Beier (1999) can be found in Sengpiel (in pressb).

ATT. Attitude determines motivation to use technology and thus will have a direct influence on successful use and an indirect influence through better experience and practice (Fishbein & Ajzen, 1975; Wagner et al., 2010). Attitude towards ticket vending machines was measured using an eight item seven point semantic differential created for this study. As expected, older adults had a less positive attitude toward TVMs (see Figure 22 and table E14 for an overview of the results).

Table 7: Attitude toward ticket vending machines mean scores of older and younger participant groups

age group	young			old		
attitude items	Mean	N	SD	Mean	N	SD
repulsive - appealing	0.35	62	1.32	-0.37	59	1.53
unpleasant - pleasant	0.31	62	1.14	-0.65	60	1.40
frustrating - encouraging	0.53	62	1.04	-0.42	59	1.68
complicated - simple	1.55	62	1.40	-0.75	61	1.63
unclear - clear	1.19	62	1.29	-0.35	60	1.54
useless - useful	2.40	62	0.86	0.92	60	1.81
inappropriate - appropriate	2.39	62	0.71	1.10	61	1.67
difficult to learn - easy to learn	1.73	62	1.04	0.02	60	1.57

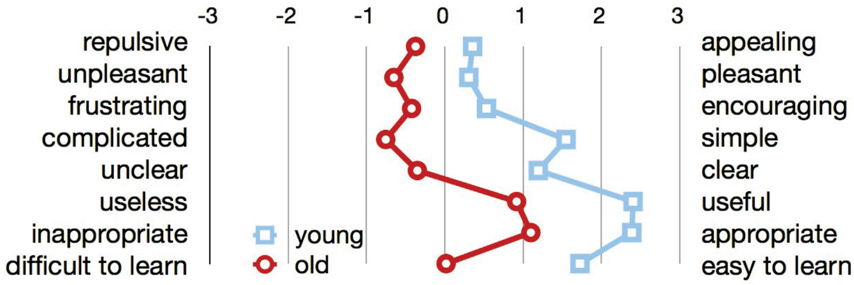

Figure 22. Semantic differential for attitudes of young and old participants toward ticket vending machines (N=59 to 62)

CATS. Computer anxiety and computer knowledge often show a strong negative correlation (eg. Karavidas et al., 2005, r=-.83, p<.01, N=222). Anxiety towards ticket vending machines was measured using an adaptation of the „Computer Anxiety Trait Scale“ (CATS) by Gaudron & Vignoli (2002), asking the participants to imagine being at the train station wanting to use a TVM and to rate their approval to 16 statements (e.g. „I sweat“, „My heart beats faster“) regarding this situation on a five-point Likert scale ranging from „not at all“ to „absolutely“.

Fluid Intelligence (WAIS DSC & LPS 50+). To measure fluid intelligence, two short subscales from the WAIS (Wechsler, 1955, Digit Symbol-Coding task, in German = HAWIE ZST, Tewes & Wechsler, 1991) and the LPS 50+ (Horn, 1983, subscale "reasoning") were chosen. They were not adapted to TVM-use, as they were considered to measure general abilities affecting TVM use. Figure 23 shows examples from both questionnaires.

The Digit Symbol-Coding task of the Wechsler Adult Intelligence Scale (WAIS DSC) asks participants to match 100 numbers (1-9) to symbols in 90 seconds (speed test) and measures mainly processing speed. The German version used in the study is called "HAWIE ZST" ("Zahlen-Symbol-Test", Tewes & Wechsler, 1991; WAIS, Wechsler, 1955; WAIS-R, Wechsler, 1981).

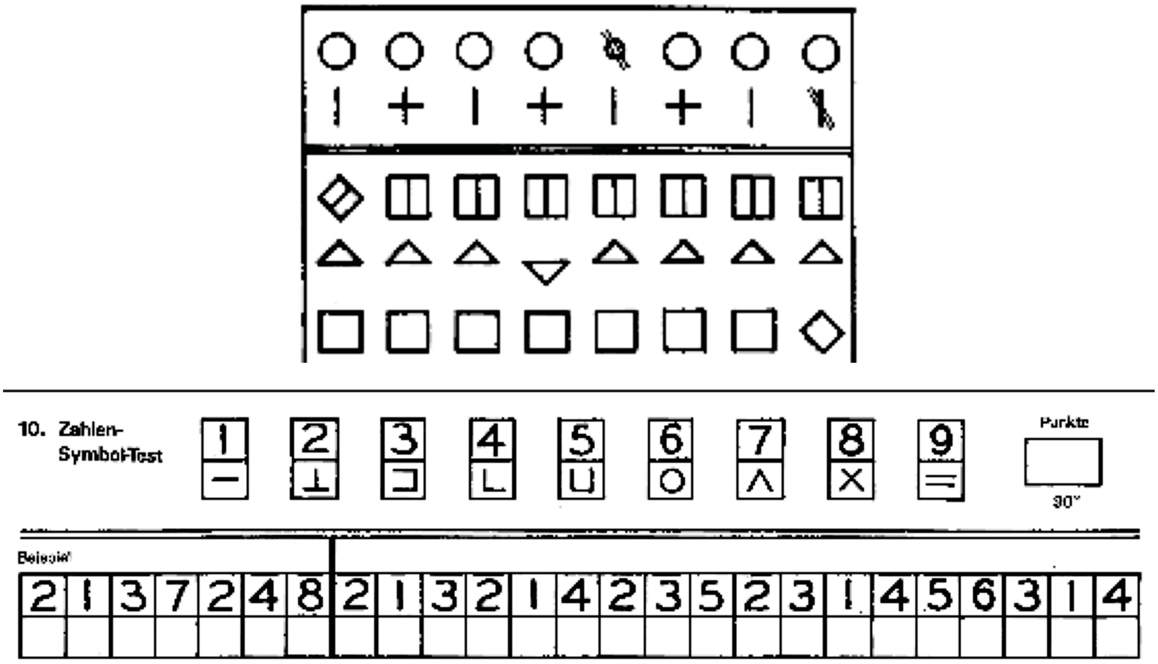

Figure 23. examples from LPS 50+ reasoning (above) and WAIS DSC (German: HAWIE ZST, below) used to test participants' fluid intelligence

The subscale "reasoning" (German: "Erkennen von Gesetzmäßigkeiten") is the third of 13 subtests of the LPS 50+ (Leistungsprüfsystem ("performance testing system") by Horn (1983). It is a 5 minute speed test containing 40 items, asking participants to mark the one symbol in a row of eight that does not fit the emergent pattern and measures mainly reasoning. The "50+" version was used for old and young participants, since it differs only in bigger items accounting for lower visual acuity.

Computer literacy scale (CLS)

Using the touch-screen-TVM investigated in this thesis, the task of selecting the desired ticket requires mainly domain knowledge about the many available ticket options ("knowledge in the world vs. in the head", Norman, 1988), yet the TVM itself requires interaction knowledge about touch screens and terms, symbols and procedures common to computer use (computer literacy), posing an additional barrier, especially to older users. Thus differences in computer literacy were expected to explain differences in successful TVM use. To measure computer literacy, it shall first be defined and operationalized.

Ever since Luehrmann (1972) and Nevison (1976) coined the term "computer literacy" (calling it „computing literacy" at first), there has been a heated debate on what it should encompass. Luehrmann begins his „sermon" with a parable (1972, p.407), in which he replaces the term „computing" with „reading and writing" and argues that we should not leave computing to specialists, but should teach it to our kids as a cultural skill. 30 years later, he reflects on a mixed success, as computers and computer literacy still have not become integrated as "thinking tools" in school curricula like reading and writing have

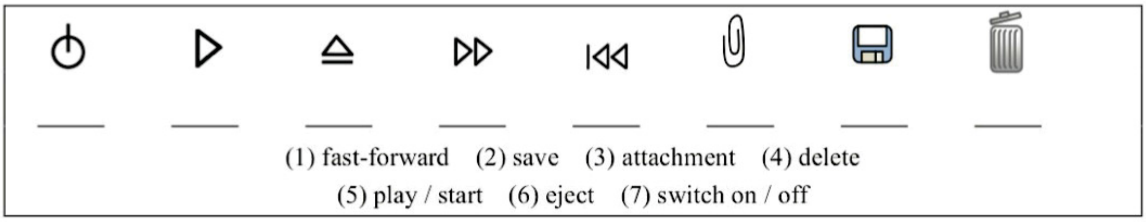

Figure 24. Sample items in the matching task of the CLS

(Luehrmann, 2002). Nevison (1976) focuses on teaching to program computers and lists 144 of the 184 courses at Dartmouth College in which computing was used in 1974/1975, while only 5 of these courses were specifically on computer science. He concludes „... Even where students do not write a program, they rely on others who do... At Dartmouth, the ability to use a computer program and, more important, the ability to write one are widespread. Computing literacy is high.“ The term "computer literacy" increased in popularity in the literature with a sharp increase starting 1977 and peaked in the late 1980s[11] (Google Ngram Viewer[12], 2014).

Today, more than 40 years later, there is still no generally agreed upon definition of computer literacy (Turner et al., 2000; Mason & Morrow, 2006). Yet there is widespread acceptance of the fact that it has great impact on the ability to interact with computers: "Just as one needs to have reading literacy to benefit from the information made available by the printing press, one must have computer literacy to benefit from the information made available by the personal computer" (Poynton, 2005, p.862). While some authors point to the importance of computer literacy as a modern cultural skill (e.g. Coy, 1998), some authors express it more drastically: „Computer literacy is a key phrase that brutally bifurcates our society“ (Cooper, 2004, p.38). It is exactly this later notion that is of interest for this thesis: computer literacy as basic interaction knowledge required for successful use of computers, that shapes and is shaped by the use of ICT and is less common among older adults (Sengpiel & Dittberner, 2008).

Measuring computer literacy proved to be even more complex than defining it. Even though there were a variety of computer literacy and related measures available, none of them were short, objective and age specific for older adults, which led to the development of the computer literacy scale (CLS, Sengpiel & Dittberner, 2008). Most reviewed publications focused on computer experience and computer anxiety or attitudes rather than knowledge or literacy (e.g. Beckers & Schmidt, 2003; Bozionelos, 2001; Garland & Noyes, 2004; Schumacher & Morahan-Martin, 2001, B. Smith et al. (2000); B. Smith et al., 2007; Potosky & Bobko, 1998), some developed measures for more specific computer knowledge, e.g. for Windows (Miller & Wooten, 1997) and the Internet (Potosky, 2007, Bradlow et al. (2002)) and only a few addressed general computer knowledge and computer literacy (e.g. Wagener, 2003; Turner et al., 2000, Winter et al., 1997 , Pyrczak, 1990).

This lack of suitable instruments had also been found by Arning & Ziefle (2008)

[11] The term „comput<u>ing</u> literacy“ remained scarcely used
[12] https://books.google.com/ngrams

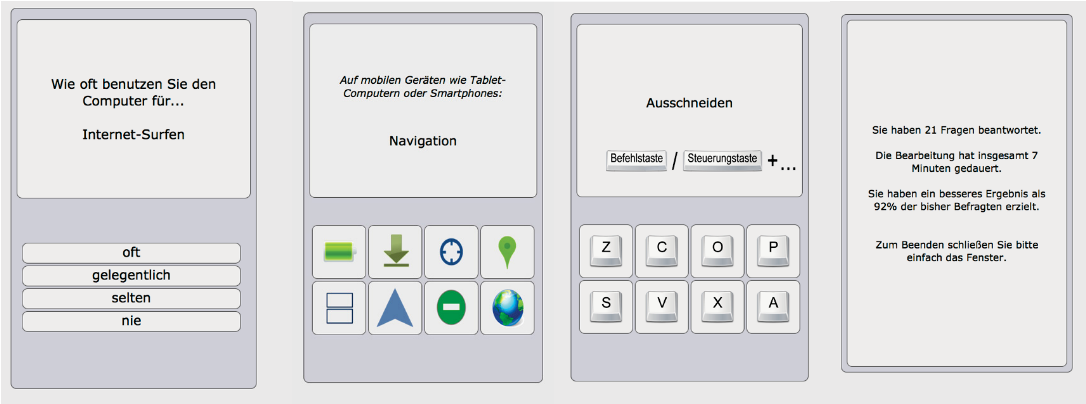

Figure 25. Screenshots with sample items from the current prototype of the adaptive CLS

for the assessment of computer expertise. Thus they created the "Computer Expertise questionnaire" (CE), which was used for validation of the CLS. Results showed that CLS and CE were moderately correlated (τ=.62, $p<.01$), which indicates that they measure related constructs, even though they do so in very different ways (Sengpiel & Dittberner, 2008). Later, Boot et al. (2013) found a similar lack of instruments and developed the "Computer Proficiency Questionnaire" (CPQ) to assess the computer proficiency of seniors (from non-users to frequent computer and Internet users), arguing that the CE by Arning & Ziefle (2008) had been developed with data from older adults who had substantial computer experience and the CLS by Sengpiel & Dittberner (2008) had been designed for older adults, but focused largely on declarative knowledge rather than the ability to perform computer tasks. The CPQ itself has shown very high reliability (Cronbach's α = .98) and consists of 33 items (there is also a short form with 12 items) that ask the respondent whether she can use technology devided in six categories: computer basics, printer, communication, Internet, calendar and entertainment. Thus, the CPQ is not a knowledge test but a self report measure. It has not yet been used to validate the CLS.

The CLS focuses on a small but essential aspect of computer literacy and uses it as indicator for the broader construct: "If literacy can be considered the ability to read symbols and use them, then computer literacy could be considered the ability to understand and use computer related symbols, functional elements and interaction patterns" (Sengpiel & Dittberner, 2008, p. 8). These basic building blocks of computer literacy are tested in an objective knowledge test with 26 items (21 symbols and 5 terms) in a matching task, taking about 15 minutes to complete, depending on literacy level. Figure 24 provides an example with seven items and one distractor from the paper version used in this study. The CLS can be downloaded for free as printable pdf[13]. It is available in English, German and Spanish[14].

While the focus on an objective test of declarative knowledge was deliberate, the lack

[13]from `www.computer-literacy.net` and from `https://www.researchgate.net/profile/Michael_Sengpiel`, an option which has been used about 40 times per week

[14]Thanks to Jose Luis for the translation and to Demian Martos for proofreading. Italian and Chinese versions have not yet been proofread

of a test of procedural knowledge mentioned by Boot et al. (2013) did not go unnoticed. Hence, further versions of the CLS have been and are still being developed, leading to four versions of the CLS thus far. The first version described above (CLS-ST for symbols and terms) has been supplemented with an interactive version (CLS-IA for interactive) that lets participants perform small computer tasks and has been published as diploma thesis by Zeissig (2009). A third version added more difficult items to extend the measurement range to more proficient users (CLS+) and has been published as bachelor thesis by Spiering (2010). Finally, a fourth version was added as an adaptive test to further reduce test duration while maintaining high reliability. To reach that goal, the item pool was extended once more and conformity to the RASCH model was verified. Again, results have been published as diploma theses by Arsenyeva (2012) and Götzinger (2014). Figure 25 shows four screenshots from the current prototype of the adaptive CLS. Current efforts are directed at making this test available online at `www.computer-literacy.net`.

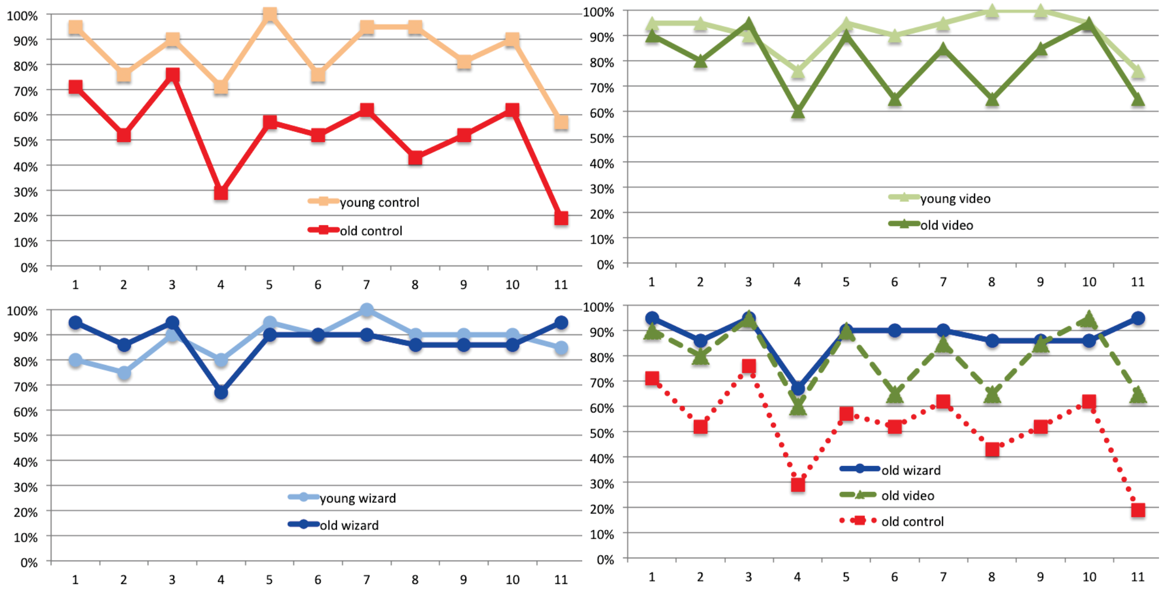

Figure 26. Effectiveness across tasks for all groups (in percent), comparing age groups for the control (top left), video (top right) and wizard (bottom left) condition. Bottom right compares effectiveness between conditions for older participants exclusively.

Results (Summary of articles)

Improving usability through video instruction and wizard redesign

The results described in detail in the articles at the back of this thesis paint an encouraging picture. For the TVM investigated, the usability for older adults could be improved greatly with relatively little effort. The video and the wizard were both successful, increasing mean effectiveness for the older groups from 52% to 80% and 88% respectively. With the original TVM, older participants solved only 62% of the number of tasks solved by the younger group, but 87% with the video instruction and 100% with the wizard. Figure 26 shows the effectiveness across tasks for all groups. Achieving the goal of universal usability could be defined as older participants reaching the effectivenss of younger participants or the 80% mean effectiveness defined by Shneiderman (2000; 1999). The results show, that the goal of universal usability of a TVM is within reach with reasonable effort, given it was achievable within a small research project such as ALISA.

The results were not as positive for the other usability criteria efficiency and satisfaction - as expected, especially age differences in efficiency measured in time remained. A MANOVA comparing the four dependent variables in all experimental conditions for both age groups revealed the significant differences marked in figure 27. Because some assumptions of MANOVA/ANOVA had been violated, a nonparametric Kruskal-Wallis test was conducted and followed up by Mann-Whitney tests, which confirmed the significant differences between experimental groups in all but two cases.

Table 8 shows the MANOVA between-subject effects in effectiveness, efficiency and

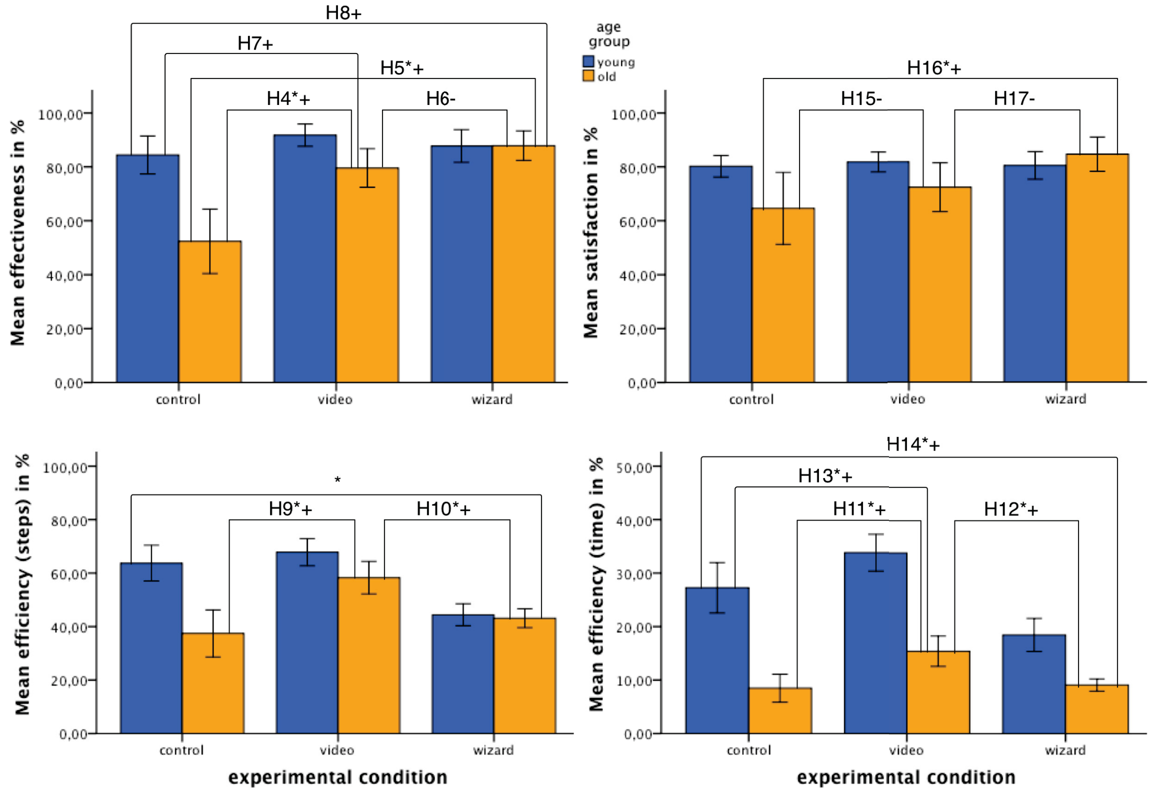

Figure 27. Mean effectiveness, satisfaction and efficiency measured in steps and in time for the two age groups and three experimental conditions. Values have been transformed to percent to allow direct comparison, higher %-values are better, the scale for efficiency (time) has been cut off at 50% for easier comparison. All significant group differences are marked with * (see table E2 for significance values with Bonferroni adjustment for multiple comparisons). Hypotheses are marked with H4 through 17, where + (-, /) denotes (not, partly) confirmed.

satisfaction for age groups and experimental conditions as well as the age group by condition interaction, including effect sizes. They indicate that age groups differed mostly in efficiency (time), explaining 45% of the variance, which can be considered a very high effect size (see Field, 2009; Kirk, 1996). In comparison, age group differences in effectiveness and efficiency (steps) both explained 12% of the variance, which can still be considered a medium to high effect size and satisfaction explained only 4%, which is a small effect. Experimental conditions differed strongly in effectiveness, efficiency (time) and efficiency (steps), each explaining 16%, 15% and 21% of the variance, respectively. Again, satisfaction explained only 5%, which is a small effect. For the age group by experimenal condition interaction effectiveness and efficiency (steps) both show medium effect sizes, each explaining 10% and 9% of the variance, respectively. Here, efficiency (time) and satisfaction explained only 3% and 5% of the variance, which is a small to medium effect.

To summarize, satisfaction differed little across age groups and experimental conditions and thus appears to be not well suited to estimate differences in intervention useful-

Table 8: MANOVA between-subject effects in effectiveness, efficiency and satisfaction for age groups and experimental conditions and the age group by condition interaction, including effect sizes

age group	F	df	error df	Sig.	η_p^2	ω^2	explained variance
effectiveness	23.56	1	112	0.000	0.17	0.12	12%
efficiency (time)	150.03	1	112	0.000	0.57	0.45	45%
efficiency (steps)	26.25	1	112	0.000	0.19	0.12	12%
satisfaction	5.89	1	112	0.017	0.05	0.04	4%
condition							
effectiveness	15.67	2	112	0.000	0.22	0.16	16%
efficiency (time)	25.68	2	112	0.000	0.31	0.15	15%
efficiency (steps)	22.36	2	112	0.000	0.29	0.21	21%
satisfaction	4.16	2	112	0.018	0.07	0.05	5%
age group x condition							
effectiveness	10.40	2	112	0.000	0.16	0.10	10%
efficiency (time)	5.70	2	112	0.004	0.09	0.03	3%
efficiency (steps)	9.80	2	112	0.000	0.15	0.09	9%
satisfaction	4.15	2	112	0.018	0.07	0.05	5%

ness[15]. The other dependent variables, effectiveness, efficiency (time) and efficiency (steps), differed rather equally across experimental conditions and very unequally across age groups, where efficiency (time) alone explained 45% of the variance. The age group by experimental condition interaction shows that in particular older participants benefit from the interventions in their effectiveness and efficiency (steps), and not so much in efficiency (time) and satisfaction.

Age related user characteristics determining successful TVM use

This section addresses the research questions, to what degree successful TVM use was determined by age related user characteristics rather than by age itself and whether computer literacy was an important predictor of successful use, even with a relatively simple TVM.

A MANOVA for the control variables showed that age groups differed significantly in the control variables, but experimental conditions did not. Thus differences in effectiveness, efficiency and satisfaction between conditions cannot be attributed to differences in these control variables, but rather to the video and wizard interventions. Correlations of usability measures and user characteristics are reported to gauge their interrelatedness. The factorial validity and reliability of the scales measuring the user characteristics were tested with a principal component analysis (PCA) and internal consistency analysis. Finally, the impact of user characteristics on usability measures in the control, video and wizard condition was

[15] A follow-up discriminant analysis revealed that the group differences shown by the MANOVA can be explained in terms of three underlying dimensions and that satisfaction had very little impact on them.

Table 9: Pearson Correlations (above the diagonal) and significance values (below the diagonal) for usability measures (N=124, except for satisfaction N=118) and user characteristics (N=102, except for satisfaction N=98)

	effective	eff(time)	eff(steps)	satisf	age	CLS	KUT	ATT	CATS	WAIS	LPS 50+
effectiveness	1	.56**	.75**	.43**	-.34**	.36**	.11	.24**	-.20*	.28**	.38**
eff (time)		1	.74**	.20*	-.62**	.63**	.38**	.44**	-.44**	.65**	.66**
eff (steps)			1	.26**	-.32**	.38**	.17*	.32**	-.30**	.41**	.47**
satisfaction		.028	.005	1	-.13	.23*	.27**	.26**	-.33**	.09	.13
age			.001	.099	1	-.76**	-.35**	-.54**	.43**	-.68**	-.70**
CLS				.012		1	.46**	.51**	-.51**	.63**	.68**
KUT	.138		.044	.004			1	.52**	-.53**	.41**	.46**
ATT	.007		.001	.005				1	-.73**	.54**	.60**
CATS	.024		.001	.001					1	-.47**	-.46**
WAIS DSC	.003			.198						1	.69**
LPS reason				.097							1

Correlation is significant at the **0.01 / *0.05 level, to improve legibility, all fields with values of .000 have been left blank

Table 10: Pearson correlations for usability measures and user characteristics in the control, video and wizard conditions

dependent variable	condition	N	age	CLS	KUT	ATT	CATS	WAIS DSC	LPS 50+
effectiveness	control	32	-.54**	.61***	.21	.48**	-.49**	.45**	.72***
	video	35	-.49**	.50**	.30*	.41**	-.20	.42**	.50**
	wizard	35	.05	.05	-.08	-.09	.09	-.06	-.01
efficiency (time)	control	32	-.69***	.67***	.41*	.43**	-.46**	.72***	.78***
	video	35	-.78***	.70***	.35*	.52**	-.35*	.63***	.70***
	wizard	35	-.66***	.63***	.47**	.44**	-.45**	.63***	.65***
efficiency (steps)	control	32	-.56***	.60***	.25	.50**	-.51**	.54**	.76***
	video	35	-.42**	.36*	.12	.29*	-.05	.38*	.38*
	wizard	35	-.01	.04	.05	.00	.07	.09	.12
satisfaction	control	32	-.26	.49**	.43**	.49**	-.47**	.17	.31
	video	35	-.27	-.01	.12	.15	-.26	.07	.03
	wizard	35	.15	.21	.29*	.15	-.36*	.09	.11

Correlation is significant at the ***0.001 / **0.01 / *0.05 level

Table 11: Effects of user characteristics on effectiveness for control, video, wizard and over all conditions

	condition	control, N=32		video, N=35		wizard, N=35		overall, N=102	
	model R^2	.619		.357		.050		.180	
block		β	sr^2	β	sr^2	β	sr^2	β	sr^2
1	ΔR^2	.295**		.236**		.002		.118***	
	age	-.54**	.29	-.49**	.24	.05	<.01	-.34***	.12
2	ΔR^2	.088^m		.037		.015		.024**	
	age	-.17	.01	-.25	.02	.18	.01	-.16	.01
	CLS	.48^m	.09	.31	.04	.18	.01	.24^m	.02
3	ΔR^2	.098		.059		.026		.009	
	age	-.17	.01	-.18	.01	.23	.02	-.13	.01
	CLS	.37	.04	.30	.04	.35	.03	.27^m	.03
	KUT	-.14	.01	.15	.02	-.15	.01	-.10	.01
	ATT	.20	.02	.26	.02	.11	<.01	.11	<.01
	CATS	-.20	.02	.30	.04	.15	.01	.02	<.01
4	ΔR^2	.138*		.025		.007		.028	
	age	.14	.01	-.07	<.01	.26	.02	-.05	<.01
	CLS	.21	.01	.28	.03	.33	.03	.21	.01
	KUT	-.17	.02	.11	.01	-.16	.01	-.13	.01
	ATT	-.15	.01	.20	.01	.10	<.01	.03	<.01
	CATS	-.40^m	.07	.26	.03	.16	.01	-.01	<.01
	WAIS DSC	-.06	<.01	.02	<.01	-.10	<.01	-.05	<.01
	LPS reason	.71**	.14	.22	.02	.16	.01	.28^m	.03

Note: ***p<.001, **p<.01, *p<.05, ^{m}p<.10

estimated using correlations and hierarchical regression. Again, main results will be reported here and a more detailed description can be found in Sengpiel (in pressb).

Usability measures and user characteristics showed a wide range of correlations. Overall, effectiveness and efficiency were related strongest to fluid intelligence, computer literacy and age, while satisfaction was related strongest to computer anxiety, control beliefs regarding technology use, and attitude toward technology. Table 9 shows an overview of all correlations for usability measures and user characteristics. These correlations differed substantially when the sample was split into the different experimental conditions (see table 10), e.g. comparing correlations between effectiveness and CLS or LPS 50+, they are very high in the control condition and drop to almost zero in the wizard condition, indicating that the wizard required less computer literacy or fluid intelligence for successful use.

Finally, hierarchical regression analyses were conducted to estimate the impact of user characteristics on usability measures. Results indicate that age correlated user characteristics explained effectiveness much better than age itself. In the control condition, computer literacy was the best predictor of effectiveness among the user characteristics related to computer use (adding CLS to the regression model, the age effect almost disappeared) and the reasoning scale of the LPS 50+ (fluid intelligence) was the best predictor overall, perhaps because using an unfamiliar machine with low usability essentially requires more general problem solving competence. In other words, the original BVG TVM did not follow the common maxim coined by Steve Krug: “Don’t make me think” (Krug, 2006). The video provided knowledge necessary to use the BVG TVM, reducing the need for guesswork and the impact of fluid intelligence and the other age related user characteristics, with a particularly strong positive change in the negative impact of computer anxiety. The wizard was designed to require less computer literacy and to have better usability overall and succeeded in reducing the impact of age and age related user characteristics to a point where it can be considered truely universally usable.

Discussion

"If it is not right do not do it; if it is not true do not say it."
— Marcus Aurelius, Meditations

Even a simple device like a TVM can pose a challenge for older users. They have less computer literacy that can guide them in the use, error recovery and exploration of new technology and since the face of technology changes quickly, generational cohort differences will persist. However, the research results found in this thesis clearly show that older adults were able to use a TVM successfully, if it had been carefully designed to accommodate their needs and capabilities. They also show that it was not age itself that predicted successful TVM use, but rather age related user characteristics that can be measured and designed for. Of these, computer literacy has proven to be a central predictor, especially if the TVM resembles a computer interface.

This process of age related characteristics dissolving the factor of chronological aging itself, is not a sign of a disintegrating aging research, but rather an immanent trait of its differentiation and development. This notion has already been described by Birren (1959, cited by P. B. Baltes, 1973) stating that "aging may be used to refer to relationships involving chronological age with the implicit assumption that such relationships are inevitably in transition to being explained by other variables without recourse to the use of the term 'age'."

Overall, results of this thesis are consistent with prior research. Specific characteristics of this thesis can be seen in the concurrent consideration of the following five issues in a comprehensive study allowing for direct comparison.

1. The direct comparison of TVM usability with and without video instruction. Here, results are consistent with findings in other publications, demonstrating successful computer based training and instruction to use ICT (Sengpiel et al., 2013; Gramß & Struve, 2009; Van Gerven et al., 2006; Wallen & Mulloy, 2006; Sierra Jr et al., 2002; McNeil & Nelson, 1991; J. B. Black et al., 1987).

2. The direct comparison of two different graphical user interfaces for the same, functionally identical TVM, BVG original vs. wizard. Here, results are difficult to compare, as the argument of Morgan (1991, p. 265) that "very few valid comparisons have been done on systems whose interfaces have been specifically designed and developed to be functionally identical" still seems to hold true. In one similar study, Connell (1998) reports a TVM error analysis comparing three TVM installed at London underground and overground train stations, the Multi Fare Machine (MFM) from 1991 and the redesigned Multi Fare Machine from 1996, as well as the Few Fare Machine (FFM) and the QuickFare (QF) machine, which had remained largely unchanged in the same period. The MFM offered the complete range of ticket types and destinations, QF was similar to MFM, but FFM offered only a small range of the ten most popular ticket prices, a design decision that is quite similar to the original BVG TVM, offering seven popular tickets on the start screen. Interestingly, in that regard, the BVG TVM incorporates FFM & MFM ideas in one device. None of the machines had touchscreen interfaces and in his analysis Connell (1998) focused on errors rather than on the usability criteria effectiveness, efficiency and satisfaction, resulting in a very detailed error analysis, e.g. reporting mechanical problems accounting for most of the (very few) FFM errors, and step order and selection problems accounting for most MFM and QF er-

rors, some of which are reminiscent of the problems participants had in the selection process using the BVG TVM. Fortunately, other researchers have used the same BVG and wizard TVM for their research, so some results can be directly compared, e.g. to Hurtienne et al. (2013), who found a similarly high impact of computer literacy measured with the CLS on effectiveness of use for the BVG TVM ($\beta = .42$) but different results for usability criteria of the BVG and wizard TVM, using partly different measures, offering differing levels of prior experience as possible explanation.

3. The direct comparison of video vs. wizard as representatives of teach and design decisions, respectively. Here, results are difficult to compare as there is no comparable study known, yet perhaps many will follow.

4. The effect of age related user characteristics on usability measures for these TVMs with a focus on older adults. Here, results can be compared to research on user characteristics. E.g. Czaja et al. (2006) report similar results in their final regression model for the use of technology, e.g. for the impact of fluid intelligence with $\beta = -.73$ (about the same value as the $\beta = -.71$ for LPS reason in the control group) and of computer anxiety with $\beta = -.57$ (a similar value to $\beta = -.40$ for CATS in the control group) but also less similar values as $R^2 = .46$ for the full model with age x cognitive abilities x computer attitudes compared to $R^2 = .61$ for the full model in the control condition and $\beta = -.07$ for age compared to $\beta = -.54$ in the control group, indicating that age seems to be much more important for effective use than for technology adoption.

Also, the results for efficiency (time) are consistent with prior research suggesting that older adults will typically take 1.5 to 2 times as long as younger adults when using the same strategy to solve a task (Fisk et al., 2004), with factor estimates for response times ranging from 2.1:1 if tasks rely heavily on motor responses to 1.2:1 when they rely more on eye movements (Jastrzembski & Charness, 2007).

Finally, another differentiator of this thesis can be seen in the focus on objective measurement of computer literacy and the development of a questionnaire to achieve it, the computer literacy scale (CLS).

The degree to which a TVM or any ICT can be used independently of age or such related user characteristics can be considered a measure of universal usability. Short term benefits of inclusive TVM design are twofold: Economically, a TVM that cannot sell tickets is useless - and a TVM that cannot sell to older adults is used less. Perhaps more importantly, such a TVM could curtail older adults' social participation, for which mobility is essential. In the long term, finding a decomposed snail at the bottom of every TVM interaction will decrease the motivation to try it again, sustaining a vicious circle of avoidance and disuse. To break this vicious circle it is essential that older users have positive experiences using TVM and other ICT, providing the positive feedback needed to find the courage to walk up to and use them (again). Fortunately, universal usability is an extensively researched and well documented craft, with a growing body of research specializing in issues involving "designing for older adults" (Fisk et al., 2009).

On the question of "teach or design", both differ in effort placed on the user and on the designer and they have different impact on effectiveness of use, efficiency and satisfaction. The main advantage of the wizard lies in the effectiveness of its use and the increased satisfaction for older users. This effectiveness comes at a price of decreased efficiency, yet using the wizard was still faster than using the original TVM and watching the instructional video beforehand, making the wizard a good choice for rare interactions. Yet even though the wizard redesign came closer to the goal of universal usability, the video instruction still has advantages. First, a video can be used if the machine itself cannot easily be changed, an issue quite relevant for most public access systems. Second, a video is easier to produce and less costly than a redesign of the GUI. Third, the interaction knowledge gained watching the video can be transferred to future uses of the TVM and render the video unnessary over time, increasing efficiency. Fourth, these instructional videos could be integrated into most existing machines to provide information when they are needed. Finally, video and wizard can be combined, an option that could be investigated in further studies.

Outlook

Other measures to improve the TVM could address a simplification of the tariff system, which could certainly simplifiy the ticket selection process. Also, simple technical modifications could help, such as adding a scanner to the TVM that reads the barcode printed on the ticket and automatically selects a duplicate for the passenger. Transferring the selection process to another device like a smart phone could help as well, but might also create new problems and does not eliminate the need for careful design for usability (Spiegel-Online, 2014).

This work joins a strong movement towards universal usability and inclusive design with a focus on public access systems. It concentrates on user characteristics predicting successful use of a TVM that was used in three different experimental conditions: (1) the original TVM used by the BVG, the major public transportation provider of Berlin, (2) the same TVM, used after watching a brief instructional video explaining basic functionality and (3) the functionally identical TVM with a redesigned wizard GUI. Generalizability to similar public access systems and ICT selection processes in general can be plausibly assumed, but needs to be tested. In particular, the ideas described could be extended from public access systems to other systems with high relevance for older adults, such as government websites, Ambient Assisted Living (AAL) and telemedicine systems.

Future work could concentrate on such transfer to other increasingly complex ICT that would benefit from universal usability. Also, the CLS should be developed further by testing its validity in diverse contexts and improve its practical application further with an adaptive version that is short, reliable and easy to intergrate in everyones research. It is argued that ultimately, computer literacy could have an impact on any ICT-interaction and thus it should be measured as control variable in any study using ICT. To learn more about age and age related user characteristics and how to accomodate them through design is a constant challenge for researchers and designers, much like it is a constant challenge for older adults to keep up with technological advances.

Conclusion

Overall, the results can be encouraging for designers and policymakers, and especially for providers of public access systems, for they show that the additional effort directed toward inclusive design is justified by the gains in usability for an aging population that is constantly growing. Perhaps, the results can even provide a building block in the growing movement to establish a culture of universal usability, given that it is not only a matter of profits, but also a matter of social and moral obligation, a "duty of *reasonable* care". After all, artifacts do have politics and universal usability should always be a concern for public access systems. Peoples' longevity is essentially a wonderful achievement, for which technological advances are in part responsible. But to follow the old adage and not only give years to life but also life to years, it is important to give older adults the attention they deserve and the support they need. And if such culture of universal usability meets economic head wind, it seems reasonable to consider legal anchoring as in the "duty of care".

Cui bono. Such claims raise the question, who would benefit from such a culture or policy. The answer may be unusual, if not surprising: Everybody would benefit. First, it is the right thing to do. Second, it helps older people now, immediately in their everyday life. Third, older adults can be seen as an "index case of bad usability". As participants in usability research, they are likely to find design flaws, partly because they have less resources to compensate for bad design. Thus, they can be likened to a litmus test of usability: If they can use the ICT in question, it is likely that younger people can use it as well, which improves the usability of ICT for everyone, especially for ICT that is rarely used. And finally, someday sooner than most of us want, we are old too and will be happy to have technology that works. We can shape the world we live in and we should do it while we can. This is water.

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Appendix A
Interview and Testing Manual (German)

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Versuchsleitfaden ALISA

Sengpiel / Felten

Inhalt

1. Begrüßung und Vorstellung des Programms
Demographie (strukturiertes Interview)
Skala der Anstrengung
CLS
KUT
Einstellung

2. Aufgabenbearbeitung
11 Aufgaben (+2)
je 1x Skala der Anstrengung

3. offene Befragung
Fragen zum Automaten
optimaler Fahrkartenkauf

4. Nachbefragung
QUIS
CATS

5. Übungen
HAWIE ZST
LPS50+ reasoning

6. Feedback Versuch

ALISA
FORSCHUNGSPROJEKT

Begrüßung und Vorstellung des Programms

Vielen Dank, dass Sie sich bereit erklären, an unserer Studie zum BVG-Automaten teilzunehmen.

Diese Studie gehört zum Forschungsprojekt ALISA, welches derzeit an der Humboldt-Universität durchgeführt wird. Ziel dieses Projekts ist es, zum einen Technik zu vereinfachen und zum anderen eine Lernunterstützung für ältere Menschen zu entwickeln, die Ihnen die Nutzung bestehender Technik erleichtern soll.

Diese Erforschung soll konkret am BVG-Fahrscheinautomaten erfolgen. Es hat sich nämlich herausgestellt, dass es vielen Menschen Schwierigkeiten bereitet, mit dem Automaten umzugehen bzw. viele ihn erst gar nicht benutzen, da er ihnen zu kompliziert erscheint.

Die heutige Studie stellt einen kleinen Ausschnitt aus diesem gesamten Projekt dar. Zusammen mit Ihnen und 40 weiteren Personen, die ebenfalls an dieser Studie teilnehmen, soll untersucht werden, ob sich die Vermittlung von Grundkenntnissen in einem Video positiv auf die Bedienung des Fahrkartenautomaten auswirkt.

Wichtig ist, sie brauchen sich keine Sorgen zu machen, dass wir irgendwelche Rückschlüsse auf Ihre Person ziehen. Uns interessieren nicht die Ergebnisse ihrer Person, sondern die ihrer Altersgruppe. Zudem werden Ihre Daten absolut vertraulich behandelt, Dritte können also die heutigen Ergebnisse nicht Ihrer Person zuordnen, es bleibt also alles vollkommen anonym. Dazu machen wir gleich im Anschluss auch eine Datenschutzvereinbarung.

Die Studie wird folgendermaßen ablaufen:

a. Zu Beginn werde ich Ihnen einige Fragen zu ihrer Person stellen.

b. Dann gebe ich Ihnen einige Fragebögen in denen es um Ihre Erfahrung mit Fahrscheinautomaten und Computern geht.

c. Anschließend werden Sie den Automaten bedienen und verschiedene Fahrscheine kaufen.

d. Danach sprechen wir über Ihren Eindruck und Ideen zur Benutzung des Automaten und ich werde Ihnen zwei weitere kurze Fragebögen zum Fahrkartenautomaten geben.

e. Schließlich möchte ich mit Ihnen noch 2 kleine Übungen machen, in denen Sie Symbole erkennen und Zahlen erinnern sollen.

f. Ganz zum Schluss würde ich von Ihnen gern erfahren, wie Sie unser heutiges Treffen, also die Untersuchung als Ganzes fanden.

Einverständniserklärung unterzeichnen lassen!

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Mathematisch-Naturwissenschaftliche Fakultät II

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Einverständniserklärung

Im Rahmen der Studie werden Sie Aufgaben an einem simulierten Fahrkartenautomaten bearbeiten. Darüber hinaus werden wir Sie schriftlich und mündlich befragen.
Wir werden Ihre Daten streng vertraulich behandeln und ausschließlich für die angegebenen Forschungszwecke verwenden. Ihre Daten werden anonym gespeichert, so dass nach Abschluss der Studie niemand von Ihren Daten auf Ihre Person schließen kann. Die Verwendung für einen anderen Zweck bedarf der nachträglichen, schriftlichen Einwilligung der untersuchten Person.
Ihre Teilnahme an dieser Studie erfolgt freiwillig und kann jederzeit abgebrochen werden. Sie können Ihre Einwilligung über die zukünftige Verwendung Ihrer Daten jederzeit widerrufen.

Mit Ihrer Unterschrift erklären Sie, dass Sie die oben aufgeführten Angaben zur Kenntnis genommen haben und an dieser Studie teilnehmen wollen.

Datum: ____________________

Familienname, Vorname: ____________________

Unterschrift: ____________________

Falls Sie Fragen zu diesem Experiment haben, können Sie sich gerne jederzeit an den Versuchsleiter wenden.

Protokoll

1. **VP.Nr.**
2. **Datum & Uhrzeit:**
3. **Besonderheiten des Teilnehmers:**

4. **Kommentare zu Beginn der Untersuchung**
   (bzgl. Automateneinstellung, Selbsteinschätzung, Berührungsangst)

5. **Vorkommnisse bei der Durchführung**

6. **Wie fit ist der Teilnehmer bei der Bedienung des FKA auf einer Skala von 1-10?**

Demografie (strukturiertes Interview)

1. Wie alt sind Sie? ....

2. Ihr Geschlecht? ❒ weiblich ❒ männlich

3. Welchen höchsten Schulabschluss besitzen Sie?

   ❒ Hauptschule ❒ Realschule ❒ Abitur/Fachabitur ❒ Fachhochschule/Universität

   ❒ Sonstiges ....

4. Welchen Beruf haben Sie ursprünglich gelernt? ....

5. Was ist Ihre derzeitige Tätigkeit?

   ❒ berufstätig ❒ arbeitslos ❒ pensioniert ❒ Student

   ❒ Sonstiges..

6. Wie oft haben Sie Fahrscheinautomaten im letzten Jahr benutzt?

   ❒ täglich ❒ wöchentlich ❒ monatlich ❒ weniger ❒ noch nie

7. Würden Sie die Benutzung von Fahrscheinautomaten im Allgemeinen vermeiden, wenn Sie Alternativen, z.B. Fahrkartenschalter, hätten? ❒ ja ❒ nein

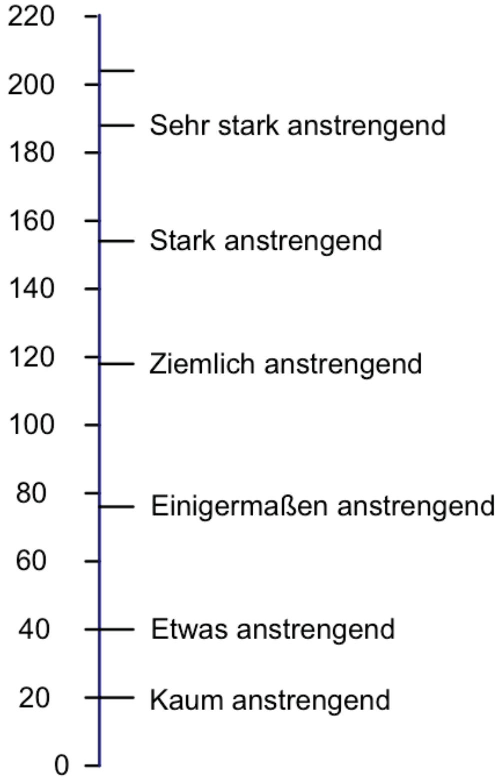
8. Wenn ja, warum würden Sie den Fahrscheinautomaten vermeiden?

ALISA FORSCHUNGSPROJEKT

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Unterhaltung für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



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Später werden Sie nach jeder Aufgabe gebeten, eine Skala dieser Art auszufüllen.

Nun möchte ich Sie bitten einige Fragebögen auszufüllen.

Worum es geht, sowie die Anleitungen zum Ausfüllen befinden sich jeweils am Anfang der Fragebögen.

Lesen Sie diese also bitte genau durch. Sollten sie etwas nicht verstehen, dann fragen Sie bitte bei mir nach.

CLS

KUT

Einstellung

HUMBOLDT-UNIVERSITÄT ZU BERLIN
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT II
KOGNITIVE ERGONOMIE - INGENIEURPSYCHOLOGIE

CLS

Im Folgenden interessiert uns, welche Erfahrungen Sie mit Computern haben. Anfangs bitten wir Sie um einige Angaben zu ihrer Nutzung von Computern. Anschließend besteht Ihre Aufgabe darin, Begriffe verschiedenen Symbolen zuzuordnen. Die Bearbeitung wird etwa 10 Minuten dauern. Bitte lesen Sie sich die Erklärung zur Bearbeitung des Fragebogens genau durch. Es ist wichtig, dass Sie alle Fragen beantworten. Vielen Dank!

Teil A: Erfahrung mit Computern

1.• Seit wie vielen Jahren benutzen Sie einen Computer? ______

Wenn sie noch nie einen Computer benutzt haben, dann springen Sie bitte direkt zum Teil B!

2.• Wie viele Stunden pro Woche benutzen Sie normalerweise einen Computer? ______

3.• Wie oft nutzen Sie Ihren Computer für folgende Tätigkeiten?

	nie	**selten**	**gelegent-lich**	**oft**	**kenne ich nicht**
Textverarbeitung	❒	❒	❒	❒	❒
Tabellenkalkulation	❒	❒	❒	❒	❒
Präsentationserstellung	❒	❒	❒	❒	❒
Bildbearbeitung	❒	❒	❒	❒	❒
Programmieren	❒	❒	❒	❒	❒
Computerspielen	❒	❒	❒	❒	❒

4.• Haben Sie Zugang zum Internet?

ja	**nein**
❒	❒

Wenn sie keinen Zugang zum Internet haben, dann springen Sie bitte direkt zum Teil B!

5.• Wenn Sie Zugang zum Internet haben, für welche Zwecke nutzen Sie das Internet?

	nie	**selten**	**gelegent-lich**	**oft**	**kenne ich nicht**
E-Mail	❒	❒	❒	❒	❒
Surfen	❒	❒	❒	❒	❒
Gezielte Informationssuche	❒	❒	❒	❒	❒
Online-Einkäufe	❒	❒	❒	❒	❒
Online-Banking	❒	❒	❒	❒	❒

Teil B: Zuordnung von Symbolen und Begriffen

Auf der nächsten Seite sehen Sie verschiedene Symbole, die für die Bedienung von technischen Geräten oder Computern relevant sind. Bitte ordnen Sie diese ihren jeweiligen Bedeutungen zu. Die Bedeutungen verfügen dabei jeweils über eine Nummer. Diese tragen Sie bitte unter das passende Symbol ein. Bitte beachten Sie dabei, dass es nicht zu jedem Symbol eine passende Bedeutung gibt, sondern <u>immer 1 Symbol übrig bleibt</u>. Die Zuordnung wird einfacher, wenn Sie die bereits zugeordneten Bedeutungen einfach durchstreichen. Zur Veranschaulichung beginnt die nächste Seite mit einem <u>Beispiel</u> mit bekannten Alltagssymbolen:

Hier ein Beispiel:

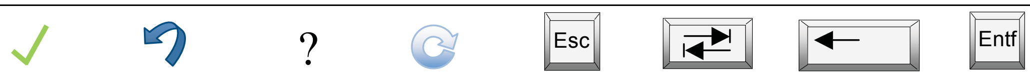
_____ _____ 1 3

~~(1) Yin-Yang~~ (2) Anhalten ~~(3) weiblich~~

Es ist nur natürlich, daß Sie nicht alle Antworten kennen. Dennoch bitten wir Sie, <u>alle</u> Bedeutungen einem Symbol zuzuordnen. Wenn Sie sich nicht sicher sind, raten Sie einfach, welche Bedeutung am besten passen könnte. Sollten Sie noch Fragen haben, steht Ihnen der Versuchsleiter gern zur Seite. Anderenfalls können Sie nun beginnen.

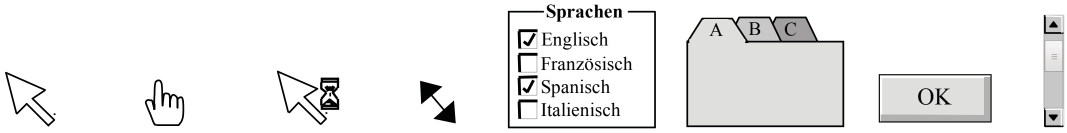
_____ _____ _____ _____ _____ _____ _____ _____

(1) Vorspulen (2) Speichern (3) Anhang (4) Löschen
(5) Abspielen/Start (6) Auswerfen/Eject (7) Ein-/Ausschalter



_____ _____ _____ _____ _____ _____ _____ _____

(1) Löschen/Backspace (2) Abbruch (3) OK/Bestätigen (4) Tabulator
(5) Hilfe (6) Entfernen (7) Rückgängig



_____ _____ _____ _____ _____ _____ _____ _____

(1) Tabs/Reiter (2) Aktionsknopf/Push Button (3) Objekt vergrößern (4) Rollbalken/Scrollbar
(5) Hintergrundaktivität/Bitte warten (6) Check Boxes/Check Button (7) Cursor/Mauszeiger allgemein

Bitte ordnen Sie nun in gleicher Weise die folgenden Begriffe ihren jeweiligen Erklärungen zu.

Datei	Cancel	Tooltip	Browser	Hyperlink	Icon
_____	_____	_____	_____	_____	_____

(1) Anwendung zum Betrachten von Inhalten im WWW (World Wide Web)
(2) Kurzer Text, der eingeblendet werden kann, wenn der Mauszeiger längere Zeit auf einem Icon verweilt
(3) Daten, die als eigenständiges Dokument unter einem gemeinsamen Namen abgelegt werden
(4) Querverweise in Hypertext-Dokumenten, die zu anderen Stellen/Seiten verzweigen
(5) Abbrechen

Vielen Dank für das Ausfüllen des Fragebogens!

VpNr.:

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KUT

Uns interessiert nun Ihre Meinung zu Problemen im Umgang mit technischen Geräten. Dazu haben wir 8 Aussagen formuliert, die sie bejahen oder verneinen können, je nach Ihrer persönlichen Ansicht. Kreuzen Sie bitte das entsprechende Feld an, wichtig ist:

Es gibt keine richtigen oder falschen Antworten, allein Ihre persönliche Meinung zählt!

Mit „technischen Problemen“ sind hier Schwierigkeiten im Umgang mit den verschiedensten Geräten aus Alltag und Beruf gemeint, z. B. bei:

- der Programmierung eines Videorecorders
- der Arbeit mit dem Computer
- der Bedienung einer Mikrowelle
- dem Kauf von Fahrkarten am Automaten

Vielen Dank!

	stimmt gar nicht	**stimmt eher nicht**	**teils/teils**	**stimmt eher**	**stimmt absolut**
Ich kann ziemlich viele der technischen Probleme, mit denen ich konfrontiert bin, allein lösen.	❒	❒	❒	❒	❒
Technische Geräte sind oft undurchschaubar und schwer zu beherrschen.	❒	❒	❒	❒	❒
Es macht mir richtig Spaß, ein technisches Problem zu knacken.	❒	❒	❒	❒	❒
Weil ich mit bisherigen technischen Problemen gut zurecht gekommen bin, blicke ich auch künftigen optimistisch entgegen.	❒	❒	❒	❒	❒
Ich fühle mich technischen Geräten gegenüber so hilflos, dass ich lieber die Finger von ihnen lasse.	❒	❒	❒	❒	❒
Auch wenn Widerstände auftreten, bearbeite ich ein technisches Problem weiter.	❒	❒	❒	❒	❒
Wenn ich ein technisches Problem löse, so geschieht das meistens durch Glück.	❒	❒	❒	❒	❒
Die meisten technischen Probleme sind so kompliziert, dass es wenig Sinn hat, sich mit ihnen auseinanderzusetzen.	❒	❒	❒	❒	❒

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KOGNITIVE ERGONOMIE - GNGENIEURPSYCHOLOGIE

Wirkung von Fahrscheinautomaten

Mit Hilfe dieses Fragebogens möchten wir erfahren, wie Fahrscheinautomaten auf Sie wirken. Sollten Sie noch nie einen Fahrscheinautomaten benutzt haben, versuchen Sie sich daran zu orientieren,

- welche Erfahrungen andere berichtet haben,
- welche Beobachtungen Sie vielleicht gemacht haben,
- oder was sie aus Erzählungen gehört haben.

Im Folgenden finden Sie eine Reihe von Begriffen, die jeweils gegensätzlich sind. Bitte entscheiden Sie, welcher Begriff besser ihre Meinung zu Fahrscheinautomaten beschreibt. Kreuzen Sie hierzu jeweils eine der 7 Antwortalternativen an. Bitte versuchen Sie, <u>alle</u> Aussagen spontan zu bewerten, denn Ihr erster Eindruck ist uns wichtig! Es gibt keine richtigen oder falschen Antworten, allein Ihre persönliche Meinung zählt!

Beachten Sie: Je weiter links Sie Ihr Kreuz setzen, desto mehr stimmen Sie dem linken Begriff zu und je weiter rechts Sie Ihr Kreuz setzen, desto mehr stimmen Sie dem rechten Begriff zu! **<u>Hier ein Beispiel:</u>**

Das Ausprobieren neuer Technologien ist …								
Langweilig	☐1	☐2	☐3	☐4	☐5	☒6	☐7	spannend

Haben Sie versehentlich ein Kreuz falsch gesetzt, so kreisen Sie dieses ein und kreuzen Sie die für Sie zutreffende Alternative an.

Vielen Dank!

Fahrscheinautomaten wirken auf mich …								
abstoßend	☐1	☐2	☐3	☐4	☐5	☐6	☐7	ansprechend
unangenehm	☐1	☐2	☐3	☐4	☐5	☐6	☐7	angenehm

Die Bedienung von Fahrscheinautomaten ist …								
frustrierend	☐1	☐2	☐3	☐4	☐5	☐6	☐7	ermutigend
kompliziert	☐1	☐2	☐3	☐4	☐5	☐6	☐7	einfach
unüberschaubar	☐1	☐2	☐3	☐4	☐5	☐6	☐7	überschaubar

Fahrscheinautomaten erscheinen mir …								
überflüssig	☐1	☐2	☐3	☐4	☐5	☐6	☐7	nützlich
unzweckmäßig	☐1	☐2	☐3	☐4	☐5	☐6	☐7	zweckmäßig
schwer erlernbar	☐1	☐2	☐3	☐4	☐5	☐6	☐7	leicht erlernbar

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Aufgabenbearbeitung Instruktion

Dann kommen wir jetzt zum praktischen Teil. Sie sehen hier einen Bildschirm, auf dem der BVG-Fahrscheinautomaten dargestellt ist. Sie bedienen ihn wie den tatsächlichen Automaten durch Berühren des Bildschirms.

Ich werde sie nacheinander bitten, verschiedene Fahrscheine zu kaufen. Dabei gebe ich Ihnen einen Zettel, auf dem Sie die Aufgabe nochmals lesen können.

Danach beginnen Sie bitte mit dem Kauf der Fahrkarte, indem sie auf „nächste Aufgabe" drücken. Anschließend erscheint der Fahrkartenautomaten der BVG. Nun kaufen Sie bitte die gewünschte Fahrkarte.

Da Sie bei diesem Automaten kein Geld einwerfen können, beenden Sie den Kaufvorgang, indem sie auf „jetzt bezahlen" drücken.

Mit Beendigung des Kaufvorgangs werden Sie eine Bestätigung darüber sehen, welchen Fahrschein Sie gekauft haben. Drücken Sie wieder auf „nächste Aufgabe" und wählen Sie den nächsten gewünschten Fahrschein aus.

Nach jedem Kauf gebe ich Ihnen ein Blatt Papier auf dem sie bewerten sollen, wie anstrengend sie die Aufgabenbearbeitung fanden, also nicht die Aufgabe an sich, sondern das Bearbeiten der Aufgabe.

Zunächst möchte ich Ihnen jedoch noch einige Grundbegriffe erklären, die von der BVG benutzt werden.

Domainwissen allgemein

Tarifgebiet
Berlin und das Umland gliedern sich in die Teilbereiche A, B und C. (Karte zeigen) A ist die Berliner Innenstadt bis zum S-Bahn-Ring, B ist außerhalb des S-Bahn-Rings bis zur Stadtgrenze und C ist das Umland. Bei den Fahrscheinen gibt es allerdings nur Kombinationen der Teilbereiche. Also AB, BC und ABC, die sich im Preis unterscheiden.

Einzelfahrschein und Tageskarte

Zu den gebräuchlichsten Fahrscheinen zählen der Einzelfahrschein, der zu nur einer Fahrt berechtigt und die Tageskarte, mit der man wie der Name schon sagt, den ganzen Tag fahren kann.

Regeltarif und Ermäßigungstarif
Es gibt zwei Preiskategorien, zum einen den Regeltarif. Dies ist der Normalpreis, den z.B. ein Erwachsener zu zahlen hat. Und den Ermäßigungstarif, den z.B. Kinder zahlen müssen.

Haben Sie noch Fragen? Wenn nicht, dann kommt hier die erste Aufgabe.

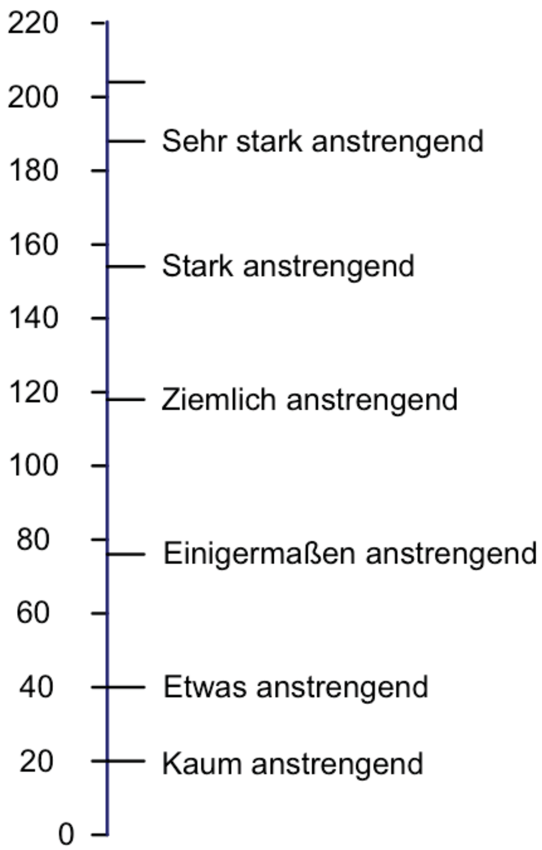
0. Aufgabe (Übungsaufgabe)

Bitte kaufen Sie einen **Einzelfahrschein** für das Tarifgebiet Berlin **AB Regeltarif**.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



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FORSCHUNGSPROJEKT

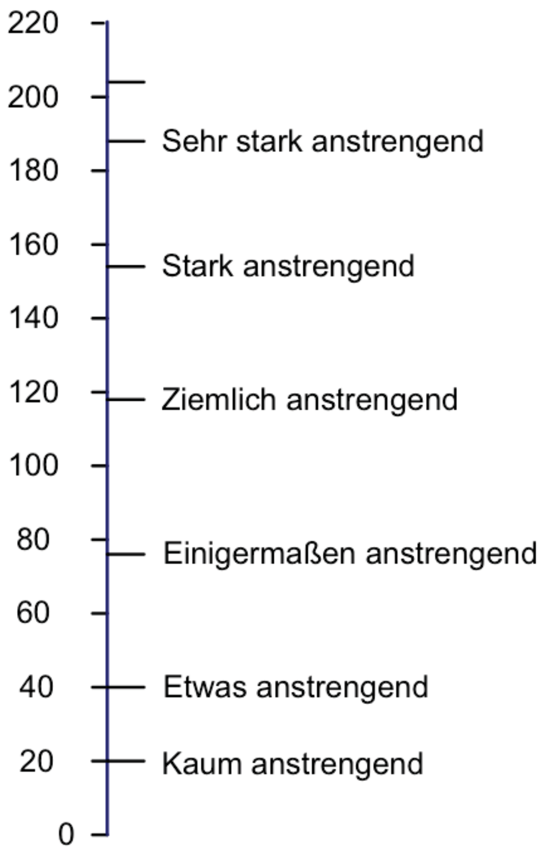
1. Aufgabe

Bitte kaufen Sie einen **Einzelfahrschein** für das Tarifgebiet Berlin **ABC Ermäßigungstarif** .

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA FORSCHUNGSPROJEKT

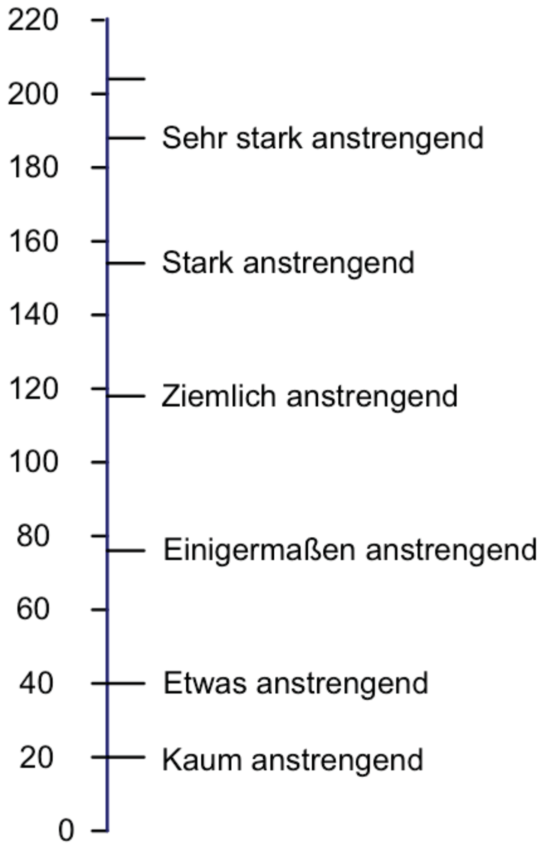
2. Aufgabe

Bitte kaufen Sie eine **7-Tage-Karte** für die **Landkreise Oberhavel und Barnim**, **ohne Ermäßigung (Standard).** Die 7-Tage-Karte soll ab dem 03. Mai gültig sein.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



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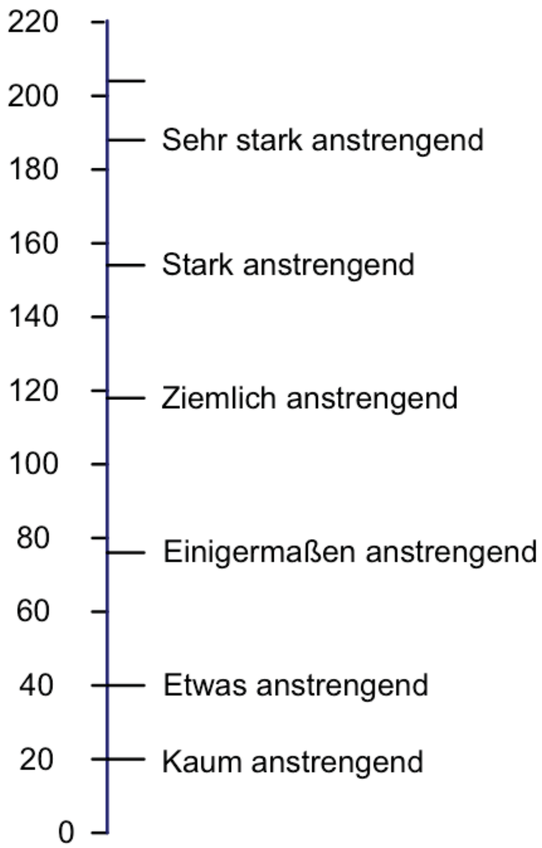
3. Aufgabe

Bitte kaufen Sie eine **Monatskarte** für den Monat **Mai**. Sie möchten den Ermäßigungstarif **Azubi** für den Landkreis **Havelland**.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA
FORSCHUNGSPROJEKT

4. Aufgabe

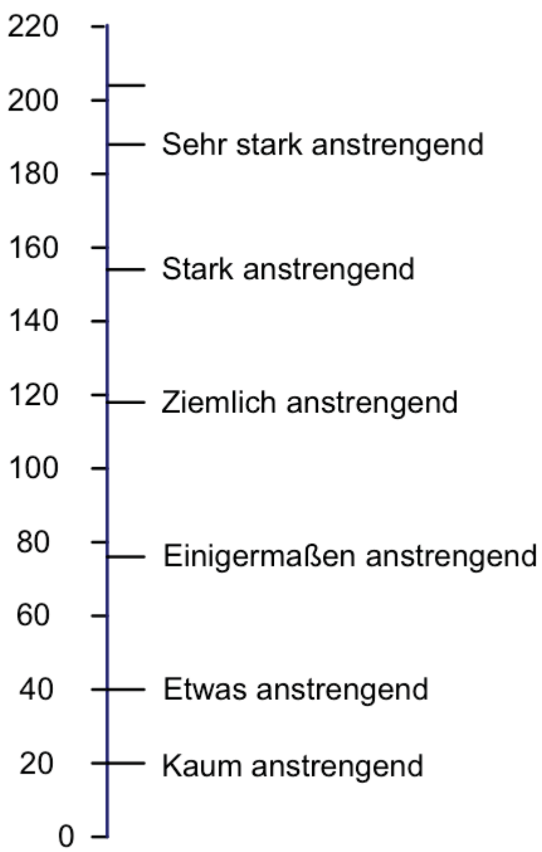
Bitte kaufen Sie eine **Monatskarte** für den Monat **Mai** für das Tarifgebiet Berlin **AB** ohne Ermäßigung (**Umweltkarte**). Zusätzlich kaufen Sie bitte einen **Anschlussfahrschein C**.

Wichtig: Kaufen Sie bitte beide Fahrscheine in einem Kaufvorgang, so dass Sie sie zusammen bezahlen können!

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



5. Aufgabe

Teil 1

Kaufen Sie bitte eine **Monatskarte-gleitend** für das Tarifgebiet Berlin **AB**, ohne Ermäßigung, ab dem **5. Mai**. Bezahlen Sie diesmal aber noch **nicht**, sondern lösen Sie bitte erst Teil 2 der Aufgabe.

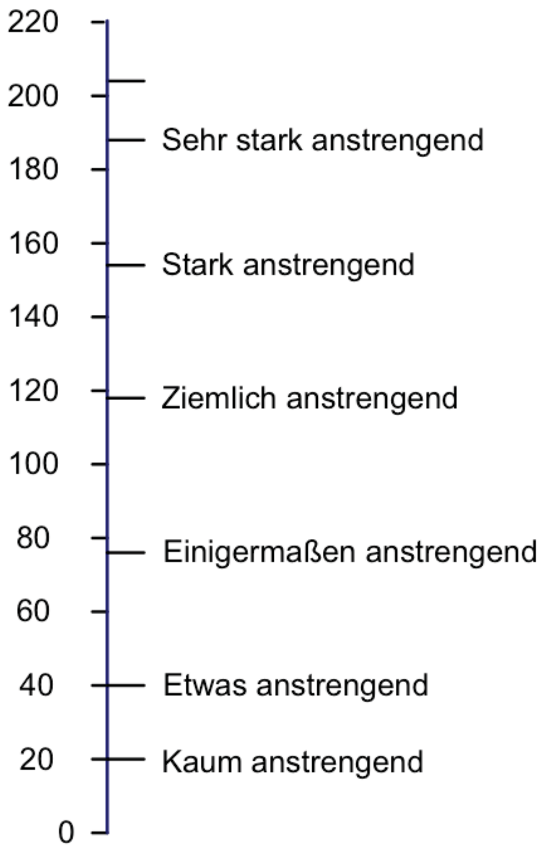
Teil 2

Ihnen fällt ein, dass Sie das falsche Tarifgebiet gewählt haben, statt AB, möchten Sie **ABC** kaufen. Bitte kaufen Sie nun eine **Monatskarte-gleitend** für das Tarifgebiet Berlin **ABC**, ohne Ermäßigung, ab dem **5. Mai**.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA FORSCHUNGSPROJEKT

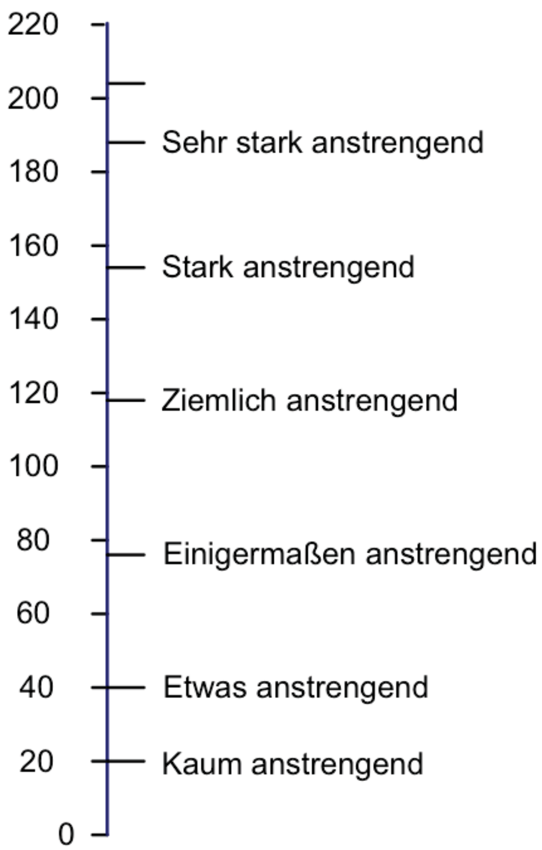
6. Aufgabe

Kaufen Sie bitte jeweils eine **Kurzstreckenkarte** für **sich** (Regeltarif), Ihr **Kind** (Ermäßigt) und Ihr **Fahrrad** in einem Kaufvorgang.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA FORSCHUNGSPROJEKT

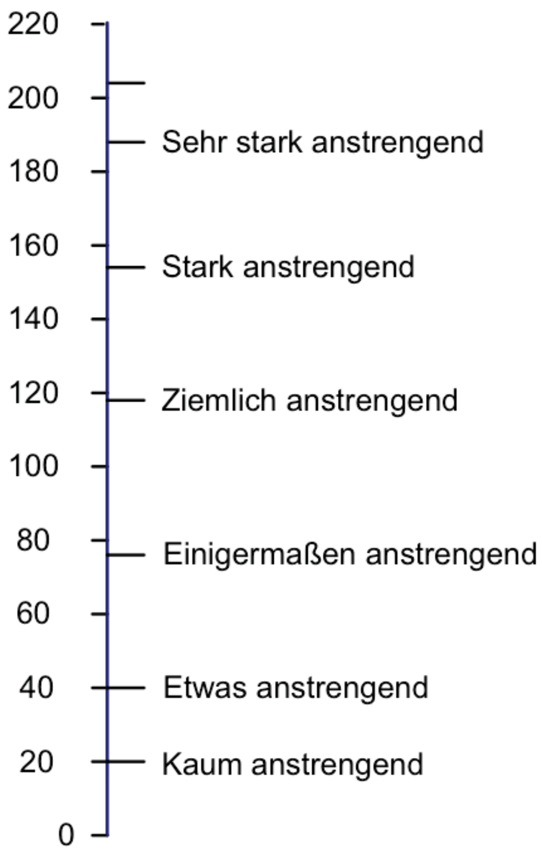
7. Aufgabe

Sie sind mit Freunden unterwegs und benötigen **2 Kleingruppenkarten** für Berlin **ABC**.
Bitte kaufen Sie die Fahrscheine in einem Kaufvorgang.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA FORSCHUNGSPROJEKT

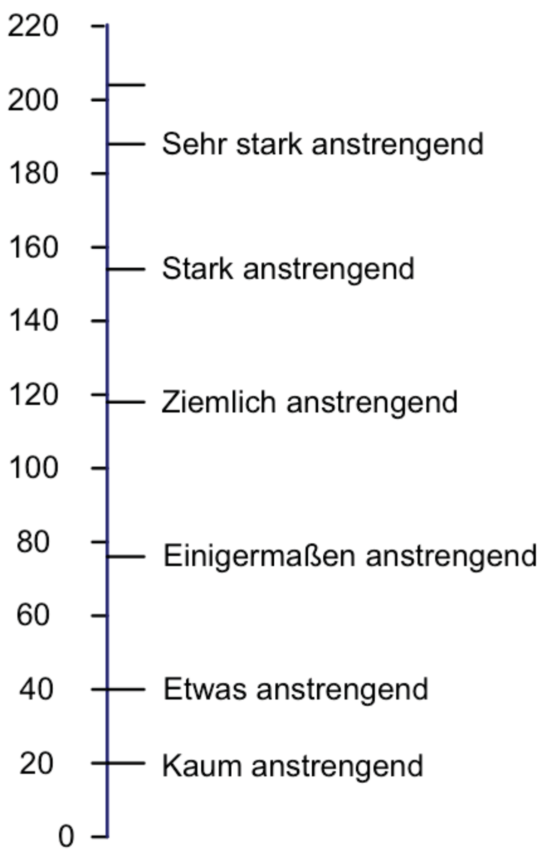
8. Aufgabe

Bitte kaufen Sie in einem Kaufvorgang **2 Monatskarten** (**Umweltkarte**) für den Landkreis Teltow Fläming. Eine Monatskarte soll für **Mai** und die andere für **Juni** gelten.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



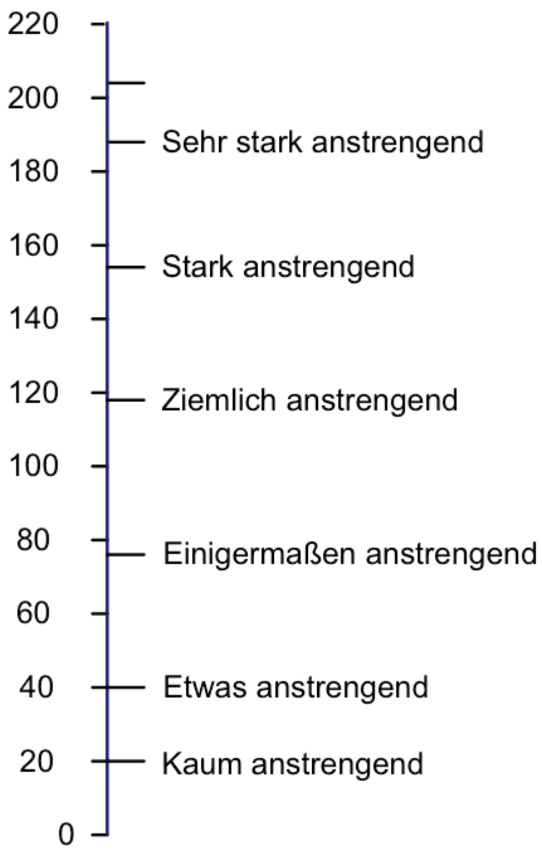
9. Aufgabe

Ein **Auszubildender** benötigt ab dem **16. Mai** einen Fahrschein für die Landkreise **Oder-Spree** und **Frankfurt/Oder**. Die Karte soll **eine Woche** gelten. Bitte kaufen Sie ihm den Fahrschein.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



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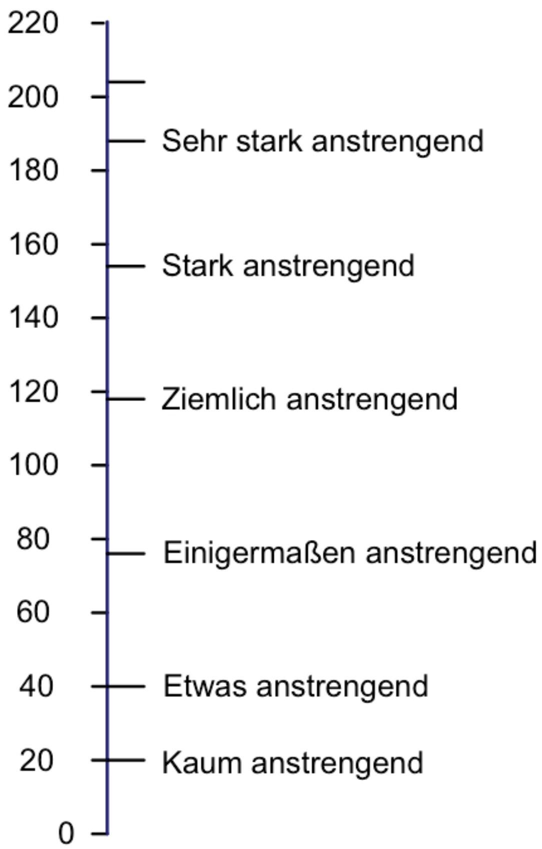
10. Aufgabe

Bitte kaufen Sie einen Fahrschein für den Monat **Mai** für den Tarifbereich **B und C**. Ihnen reicht es, nach **10:00 Uhr** loszufahren.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA
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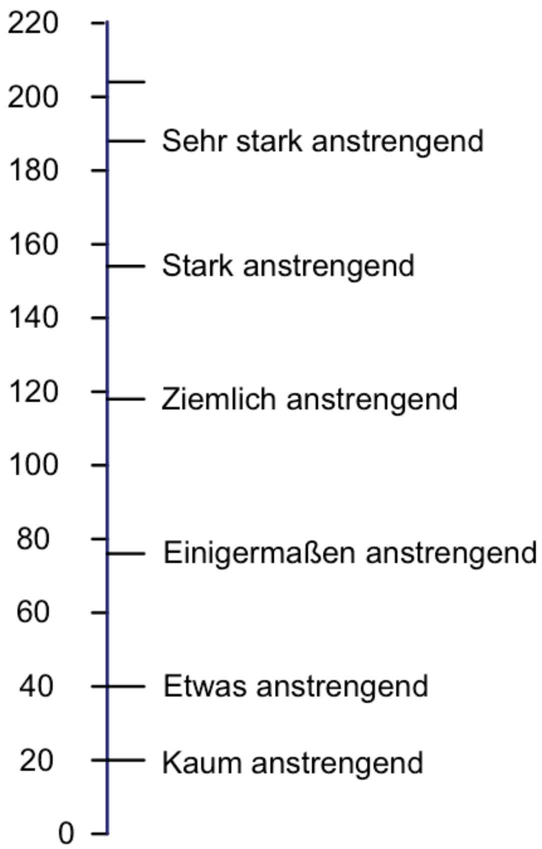
11. Aufgabe

Ein **Schüler** benötigt ab dem **25. Juni** eine **Monatskarte** für den gesamten Tarifbereich **Berlin/Brandenburg**. Bitte kaufen Sie ihm den Fahrschein.

Skala der Anstrengung

Bitte bewerten Sie, wie anstrengend diese Aufgabe für Sie war.

Kreuzen Sie die Stelle auf der Skala an, welche Ihrer wahrgenommenen Anstrengung entspricht.



ALISA
FORSCHUNGSPROJEKT

Offene Befragung

< Nachdem die Vp auf „nächste Aufgabe“ gedrückt hat, erscheint wieder der Automat mit der Überschrift: „Aufgabe: Befragung durch Versuchsleiter“. Dies dient der Veranschaulichung während der Nachbefragung und geht, nicht in die Auswertung der logfiles ein. >

Nachdem Sie nun den Fahrscheinautomaten bedient haben, würde ich gern noch einige Kleinigkeiten von Ihnen wissen.

1.• Hat Ihnen das Video bei der Benutzung des Automaten geholfen?

2.• Wenn ja/nein warum?

3.• Was hat Ihnen bei der Benutzung des Automaten besonders gut gefallen?

4.• Was fanden Sie schlecht bei der Benutzung des Automaten?

Fragen zum IA-Wissen (dabei auf FKA zeigen):

5.• Welche Bedeutung hat die blaue Schaltfläche?

6.• Welche Bedeutung hat die zweite Schaltfläche?

7.• Welche Bedeutung hat die rote Schaltfläche?

8.• Welche Bedeutung hat die unterste gelbe Schaltfläche?

9.• Welche Bedeutung hat die Schaltfläche mit dem Pfeil nach unten?

10.•Welche Bedeutung hat die Schaltfläche mit dem Pfeil nach oben?

11.•Was bedeutet es, wenn die Schaltfläche grün markiert ist? *(Am Beispiel Einzelfahrschein)*

•

Optimaler Fahrkartenkauf

Um die richtige Fahrkarte zu kaufen, sind eine Reihe von Angaben notwendig. Welche sind dies und in welcher Reihenfolge sollten sie ihrer Meinung nach erfragt werden? Bitte die Reihenfolge durch vorangestellte Zahlen kenntlich machen.

ALISA FORSCHUNGSPROJEKT

Im Folgenden gebe ich Ihnen noch zwei Fragebogen, um zu erfahren, wie zufrieden Sie mit einzelnen Aspekten des Automaten sind und ob die Benutzung für Sie Stress verursacht hat.

QUIS

CATS

VpNr.:

HUMBOLDT-UNIVERSITÄT ZU BERLIN
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT II
KOGNITIVE ERGONOMIE - INGENIEURPSYCHOLOGIE

Zufriedenheit mit dem BVG-Fahrscheinautomaten

Mit diesem Fragebogen möchten wir gern erfahren, wie zufrieden Sie mit der Benutzung des Fahrscheinautomaten waren. Dazu nehmen Sie bitte zu folgenden 11 Aussagen jeweils eine Bewertung vor, indem sie je eine der 9 Antwortalternativen ankreuzen.

Beachten Sie: Je weiter links Sie Ihr Kreuz setzen, desto mehr stimmen Sie dem linken Begriff zu und je weiter rechts Sie Ihr Kreuz setzen, desto mehr stimmen Sie dem rechten Begriff zu!

Trifft für Sie die jeweilige Aussage auf den BVG-Automaten nicht zu, setzen Sie Ihr Kreuz bitte (rechts) bei **NZ (= nicht zutreffend)**

Haben Sie versehentlich ein Kreuz falsch gesetzt, so kreisen Sie dieses ein ☒ und kreuzen Sie die für Sie zutreffende Alternative an.

Vielen Dank!

Wie ist Ihr Gesamteindruck von dem Fahrscheinautomaten …											
unangenehm	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	angenehm	☐ NZ
frustrierend	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	zufrieden stellend	☐ NZ
schwierig	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	leicht	☐ NZ

Die Zeichen auf dem Bildschirm waren …											
schwer erkennbar	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	leicht erkennbar	☐ NZ

Die Menge der auf dem Bildschirm dargestellten Informationen war …											
nicht ausreichend	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	ausreichend	☐ NZ

Die Anordnung der Informationen auf dem Bildschirm war …											
unlogisch	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	logisch	☐ NZ

Der nächste Bildschirm in der Reihenfolge war …											
nicht vorhersehbar	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	vorhersehbar	☐ NZ

BITTE BLÄTTERN SIE UM!

Das Zurückgehen zum vorherigen Bildschirm war …											
unmöglich	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	leicht	❒NZ

Die Reihenfolge der für den Fahrkartenkauf notwendigen Schritte war …											
verwirrend	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	klar strukturiert	❒NZ

Die Ausdrucksweise im gesamten Fahrscheinautomaten war …											
inkonsistent	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	konsistent	❒NZ

Die Begriffe auf dem Bildschirm waren …											
unklar	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	präzise	❒NZ

Der Fahrscheinautomat informierte Sie über Schritte im Kaufvorgang .											
niemals	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	immer	❒NZ

Das Drücken der Schaltflächen führte zu einem vorhersehbaren Ergebnis.											
niemals	❒1	❒2	❒3	❒4	❒5	❒6	❒7	❒8	❒9	immer	❒NZ

VpNr.:

HUMBOLDT-UNIVERSITÄT ZU BERLIN
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT II
KOGNITIVE ERGONOMIE - GNGENIEURPSYCHOLOGIE

CATS

Stellen Sie sich bitte vor, Sie befinden sich auf einem Bahnhof und wollen einen Fahrschein-automaten benutzen.

Bitte entscheiden Sie für jede der folgenden Aussagen, inwieweit Sie ihr zustimmen, indem Sie jeweils eine der fünf Antwortalternativen auswählen. Kreuzen Sie das Kästchen an, das am ehesten auf Sie zutrifft.

Bitte beachten Sie dabei:
Je weiter Sie Ihr Kreuz nach rechts setzen, desto mehr stimmen Sie der Aussage zu.

Vielen Dank!

	überhaupt nicht				**völlig**
Ich strebe derartige Erfahrungen an.	❒	❒	❒	❒	❒
Ich bin aufgeregt.	❒	❒	❒	❒	❒
Ich schwitze.	❒	❒	❒	❒	❒
Ich bin gelassen.	❒	❒	❒	❒	❒
Ich habe ein unbehagliches Gefühl.	❒	❒	❒	❒	❒
Derartige Situationen bereiten mir Vergnügen.	❒	❒	❒	❒	❒
Ich bekomme ein unruhiges Gefühl im Magen.	❒	❒	❒	❒	❒
Ich fühle mich wohl.	❒	❒	❒	❒	❒
Ich habe Angst etwas kaputt zu machen.	❒	❒	❒	❒	❒
Ich bin angespannt.	❒	❒	❒	❒	❒
Ich schätze diese Situationen.	❒	❒	❒	❒	❒
Mein Herz schlägt schneller.	❒	❒	❒	❒	❒
Ich fühle mich sicher.	❒	❒	❒	❒	❒
Ich bin ängstlich.	❒	❒	❒	❒	❒
Ich bin selbstsicher.	❒	❒	❒	❒	❒
Ich bin nervös.	❒	❒	❒	❒	❒

ALISA
FORSCHUNGSPROJEKT

Zum Schluss möchte ich noch zwei **Übungen** mit Ihnen machen. Der Hintergrund ist, dass Untersuchungen zeigen, dass bei der Benutzung von technischen Geräten wie Computern und Automaten oftmals auch weitere Einflussfaktoren eine wichtige Rolle spielen, z.B. das Erkennen von Gesetzmäßigkeiten oder Symbolen. Daher werde ich nun mit Ihnen zwei Übungen machen, bei denen ich schauen möchte, welche dieser Apekte Ihnen leicht fallen und welche Ihnen weniger gut liegen.

HAWIE ZST••

Instruktion

Bei dieser ersten **Übung** geht es darum, festgelegte Symbole Zahlen zuzuordnen. Sie sehen hier *(zeigen)* diese 9 abgeteilten Kästchen. Im oberen Teil befinden sich die Zahlen 1 bis 9. Darunter sehen Sie immer ein bestimmtes Zeichen bzw. Symbol. Zu jeder Ziffer gehört also ein bestimmtes Zeichen.

Nun sehen Sie hier her (*aufs Beispiel zeigen).* Hier haben wir nur Kästchen mit Zahlen, die unteren Kästchen sind hingegen leer. Ihre Aufgabe besteht nun darin in jedes dieser leeren Kästchen (zeigen), das kleine Symbol, das zu der Zahl gehören würde, zuzuordnen.

Machen wir es mal an einem Beispiel. Hier ist eine 2, also setzen wir dieses Zeichen ein (Symbol einzeichnen). Hier ist eine 1, also setzen wir dieses Zeichen ein, hier ist eine 3, also setzen wir dieses Zeichen ein.

Was müssten Sie nun bei der 7 eintragen? *(Wenn falsche Antwort, dann berichtigen und nächstes Beispiel; auf jeden Fall alle 7 Beispiele durchgehen)*
Haben Sie das Prinzip verstanden? Dann fangen Sie jetzt bitte hier an, und füllen Sie der Reihe nach, ohne eine Zahl auszulassen, so viele Vierecke aus, wie Sie können, bis ich halt sage. ***(90 Sekunden Zeit)***.

OK, dann können Sie jetzt aufhören.

(Genau auf die Zeit achten! Stoppen!)

10. Zahlen-Symbol-Test

1	2	3	4	5	6	7	8	9
–	⊥	⊐	L	⊔	O	∧	X	=

Punkte

90"

Beispiel

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

11. Gemeinsamkeitenfinden Abbruch nach 4 falsch oder unbeantworteten Aufgaben in Folge	2, 1 oder 0 Punkte
1. Apfelsine–Banane	
2. Norden–Westen	
3. Mantel–Anzug	
4. Schiff–Auto	
5. Ellenbogen–Knie	
6. Schokolade–Speiseeis	
7. Buch–Fernseher	
8. Auge–Ohr	
9. Ei–Samen	
10. Tisch–Stuhl	
11. Luft–Wasser	
12. Gedicht–Standbild	
13. Lob–Strafe	
14. Fliege–Baum	
15. Arbeit–Spiel	
16. Zoo–Bücherei	
	Maximum = 32
gesamt	

Instruktion •

Bei dieser letzten **Übung** geht es darum, Gesetzmäßigkeiten zu erkennen. Hier sehen Sie eine Zeile mit acht Kreisen. Der kleine Kreis ist durchgestrichen, da alle anderen groß sind. Die Gesetzmäßigkeit ist „große Kreise“, also passt der kleine Kreis nicht.

In der zweiten Zeile sehen sie Striche und Kreuze. Warum ist der letzte Strich falsch und somit durchgestrichen worden?
(wenn falsche Antwort, nochmals erklären)

Gut, Sie sehen wieder Reihen mit jeweils 8 Symbolen. In jeder Reihe befindet sich ein Symbol, das am wenigsten in die Zeile hinein passt. Es ist immer nur eines von den 8 Symbolen falsch.

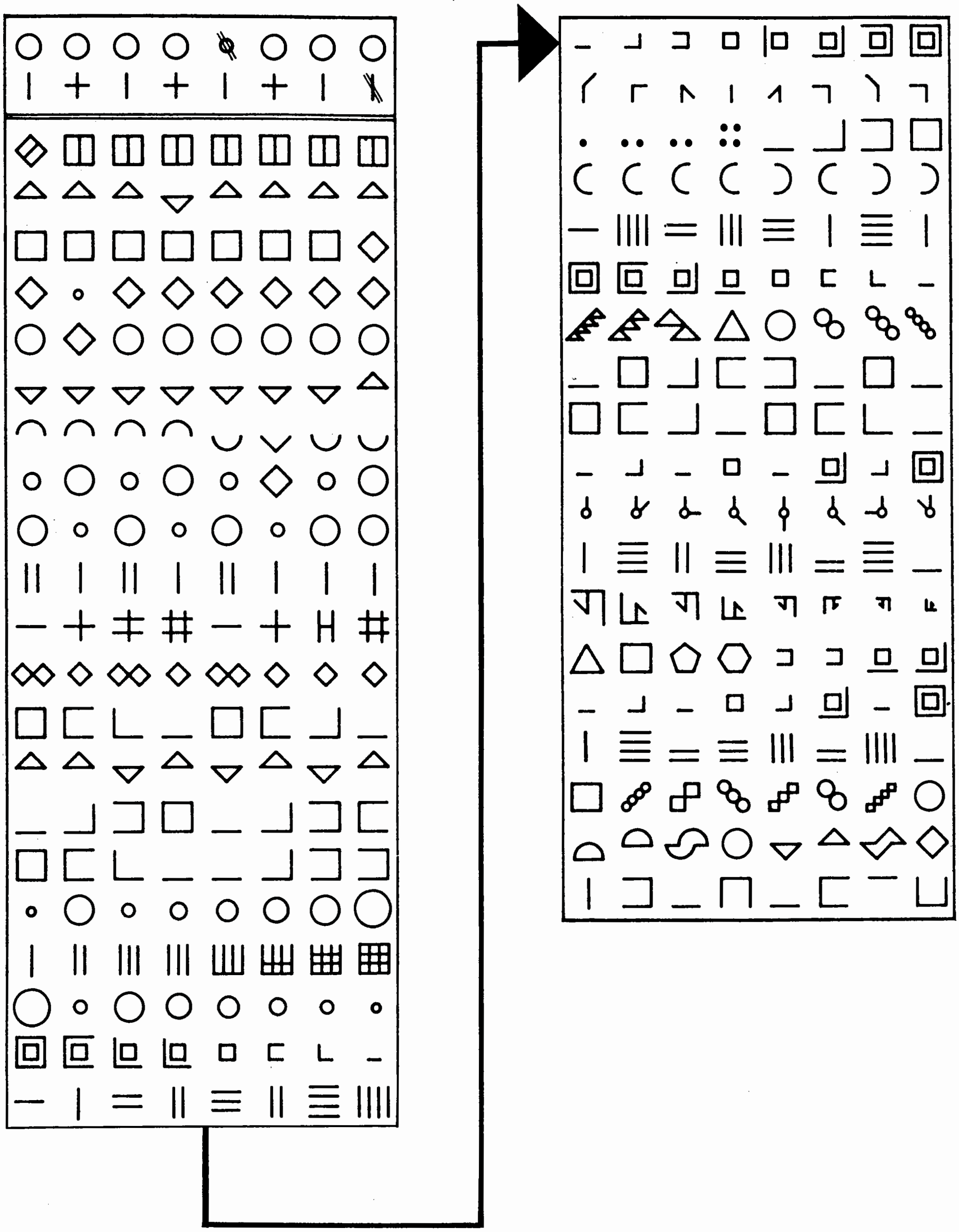
Sie müssen also auf die Unterschiede zwischen den einzelnen Symbolen achten. Versuchen Sie die Gesetzmäßigkeit in dieser Zeile zu erkennen. Anschließend schauen Sie, welches Symbol nicht hineinpasst und streichen dieses durch.

Immer dann, wenn Sie nicht herausfinden können, welches Zeichen oder Glied einer Zeile falsch ist, gehen Sie bitte sofort weiter zu nächsten Zeile und versuchen dort, den Fehler zu finden.

In jeder Zeile ist immer nur ein Symbol falsch. Auch bei dieser Übung werden sie wieder nur eine bestimmte Zeit haben. Die Zeit für die Bearbeitung ist sehr kurz, ist können im Grunde nicht alle Reihen bearbeitet werden. Versuchen Sie aber trotzdem so viele Reihen wie möglich zu bearbeiten.

Sie haben jetzt **fünf Minuten** Zeit.

3



Dank und Feedback Versuch••

Dann möchte ich mich an dieser Stelle nochmals ganz herzlich bei Ihnen für Ihre Mitarbeit an unserer Studie bedanken. Wenn Sie möchten, beantworte ich Ihnen gern noch Fragen zum Fahrscheinautomaten oder zum Kauf von Fahrscheinen.

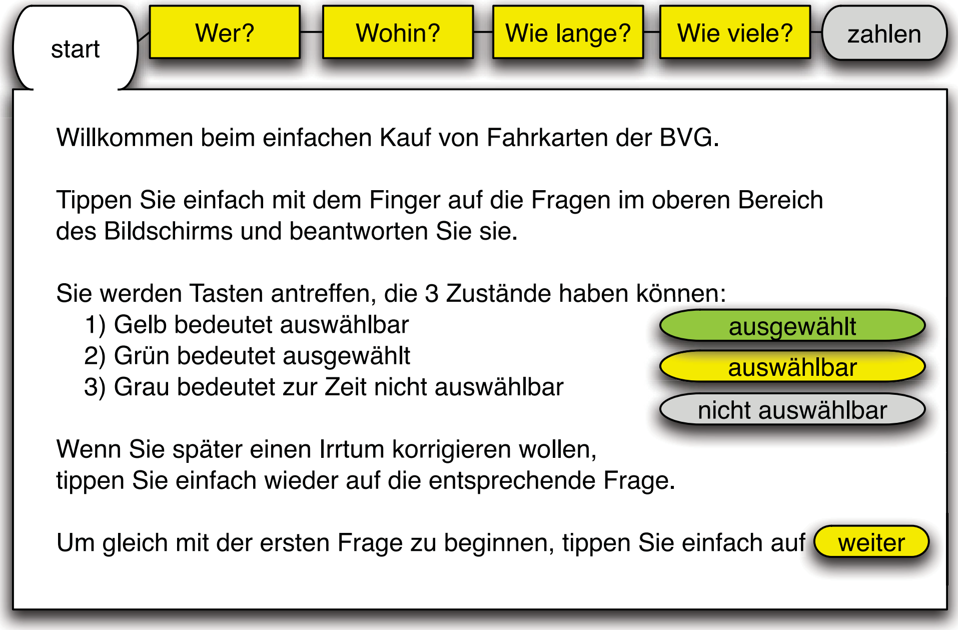
Zuvor würde ich allerdings gern noch von Ihnen erfahren, wie Sie Ihnen unser heutiges Treffen, also die Untersuchung gefallen hat. Was war gut und was hätte besser sein können?

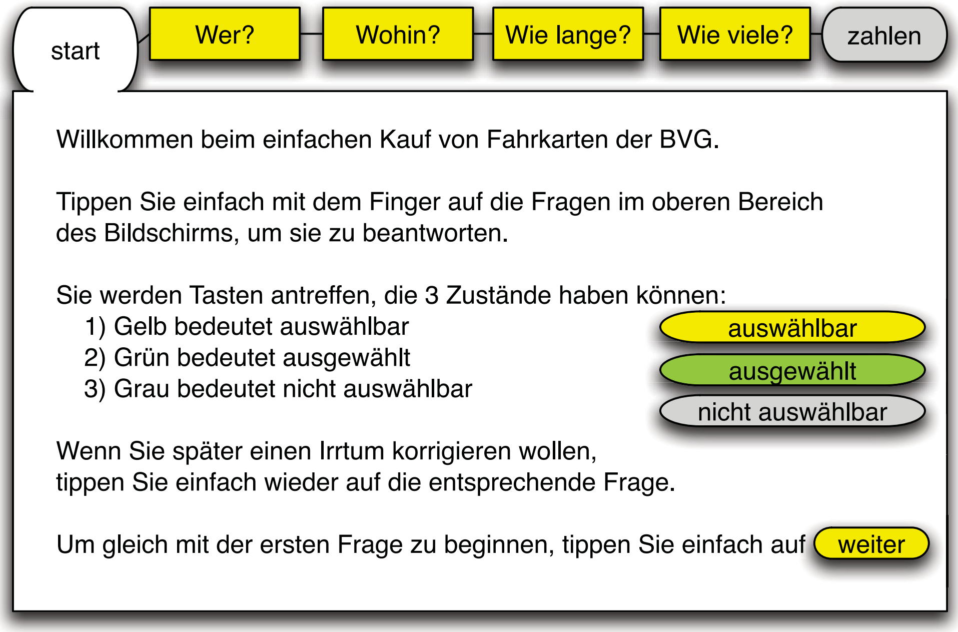
+ Kärtchen für weitere Untersuchungen mitgeben
(und auf PESA aufmerksam machen)

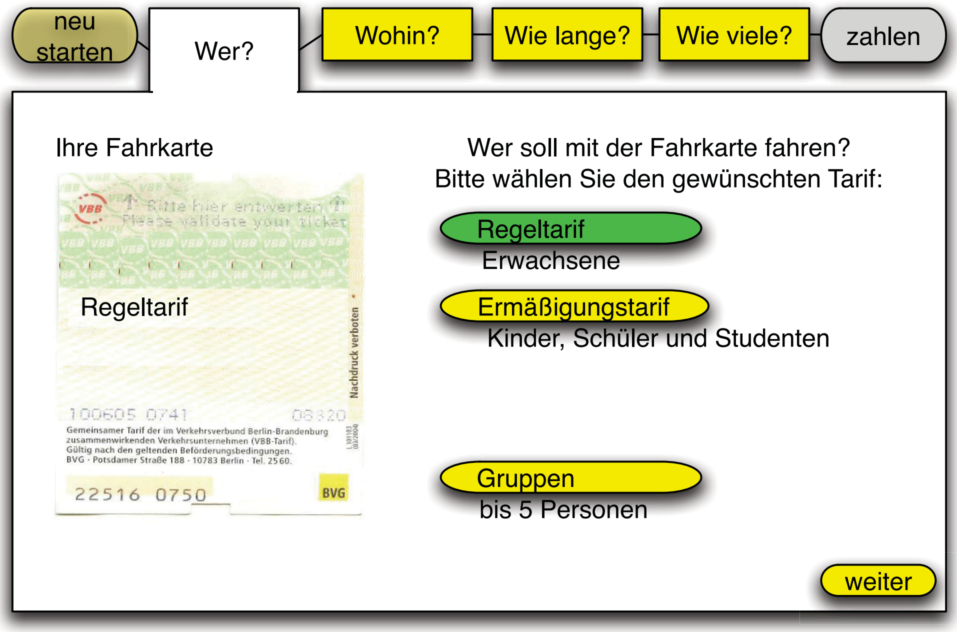
Bemerkungen

>> Ende <<

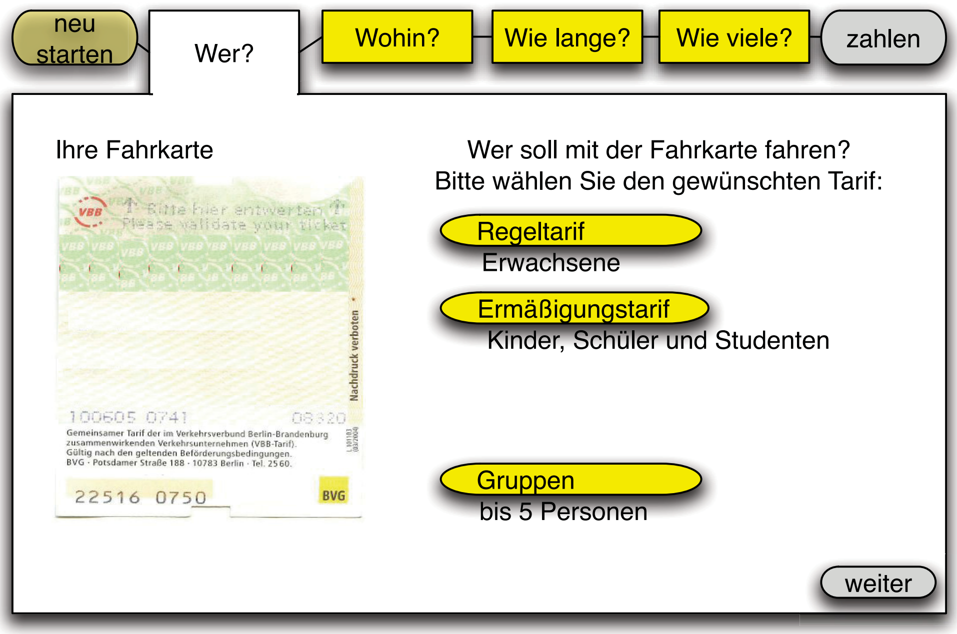
Appendix B
Prototype for the wizard redesign (German)


start
Wer?
Wohin?
Wie lange?
Wie viele?
zahlen
Willkommen beim einfachen Kauf von Fahrkarten der BVG.
Tippen Sie einfach mit dem Finger auf die Fragen im oberen Bereich des Bildschirms und beantworten Sie sie.
Sie werden Tasten antreffen, die 3 Zustände haben können:
1) Gelb bedeutet auswählbar
2) Grün bedeutet ausgewählt
3) Grau bedeutet zur Zeit nicht auswählbar
ausgewählt
auswählbar
nicht auswählbar
Wenn Sie später einen Irrtum korrigieren wollen, tippen Sie einfach wieder auf die entsprechende Frage.
Um gleich mit der ersten Frage zu beginnen, tippen Sie einfach auf
weiter

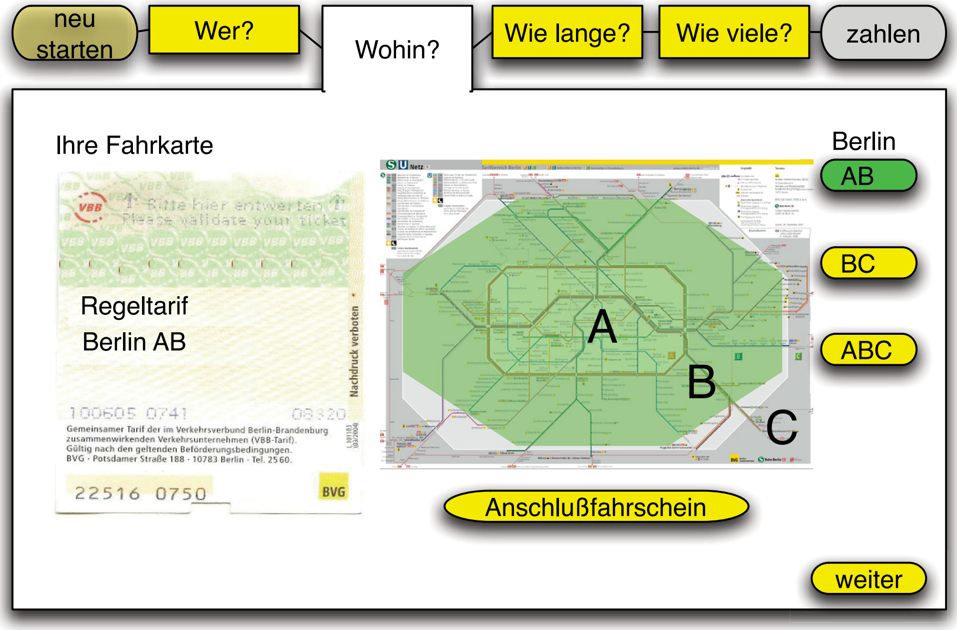

start
Wer?
Wohin?
Wie lange?
Wie viele?
zahlen
Willkommen beim einfachen Kauf von Fahrkarten der BVG.
Tippen Sie einfach mit dem Finger auf die Fragen im oberen Bereich des Bildschirms, um sie zu beantworten.
Sie werden Tasten antreffen, die 3 Zustände haben können:
1) Gelb bedeutet auswählbar
2) Grün bedeutet ausgewählt
3) Grau bedeutet nicht auswählbar
auswählbar
ausgewählt
nicht auswählbar
Wenn Sie später einen Irrtum korrigieren wollen, tippen Sie einfach wieder auf die entsprechende Frage.
Um gleich mit der ersten Frage zu beginnen, tippen Sie einfach auf
weiter



neu starten
Wer?
Wohin?
Wie lange?
Wie viele?
zahlen
Ihre Fahrkarte
Regeltarif
Wer soll mit der Fahrkarte fahren?
Bitte wählen Sie den gewünschten Tarif:
Regeltarif
Erwachsene
Ermäßigungstarif
Kinder, Schüler und Studenten
Gruppen
bis 5 Personen
weiter



neu starten
Wer?
Wohin?
Wie lange?
Wie viele?
zahlen
Ihre Fahrkarte
Wer soll mit der Fahrkarte fahren?
Bitte wählen Sie den gewünschten Tarif:
Regeltarif
Erwachsene
Ermäßigungstarif
Kinder, Schüler und Studenten
Gruppen
bis 5 Personen
weiter


neu starten
Wer?
Wohin?
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Ihre Fahrkarte
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Please validate your ticket
Regeltarif
Berlin AB
Nachdruck verboten
100605 0741
08320
Gemeinsamer Tarif der im Verkehrsverbund Berlin-Brandenburg zusammenwirkenden Verkehrsunternehmen (VBB-Tarif).
Gültig nach den geltenden Beförderungsbedingungen.
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22516 0750
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Berlin
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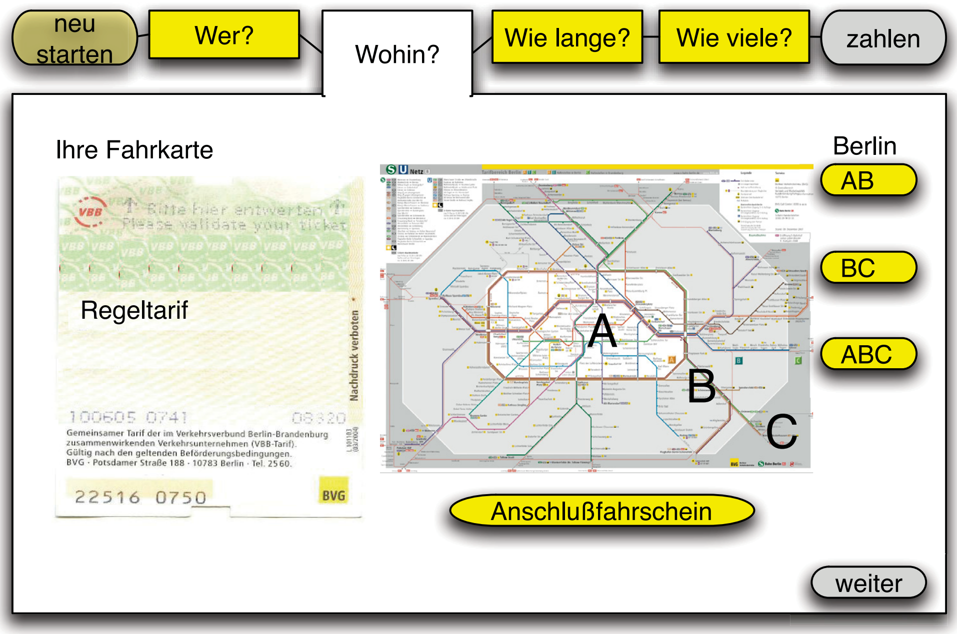
Anschlußfahrschein
weiter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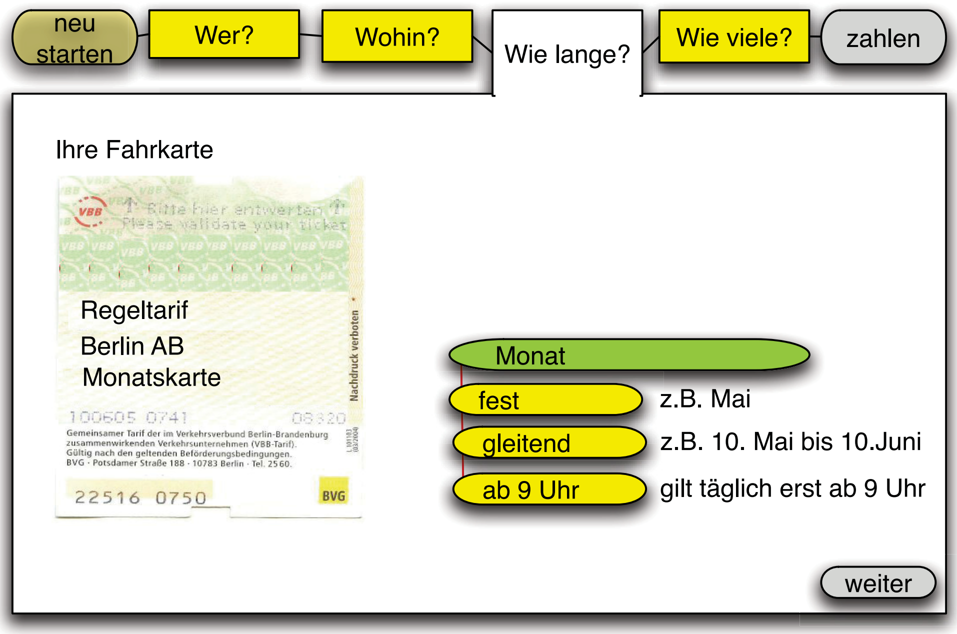
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Wie viele?
zahlen
Ihre Fahrkarte
Regeltarif
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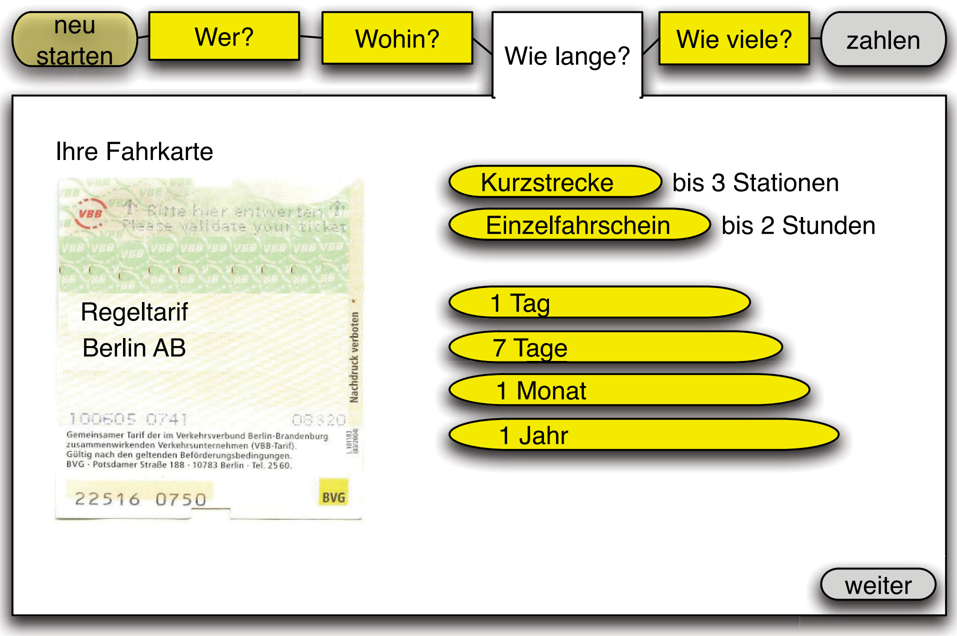
Monatskarte
Monat
fest
z.B. Mai
gleitend
z.B. 10. Mai bis 10.Juni
ab 9 Uhr
gilt täglich erst ab 9 Uhr
weiter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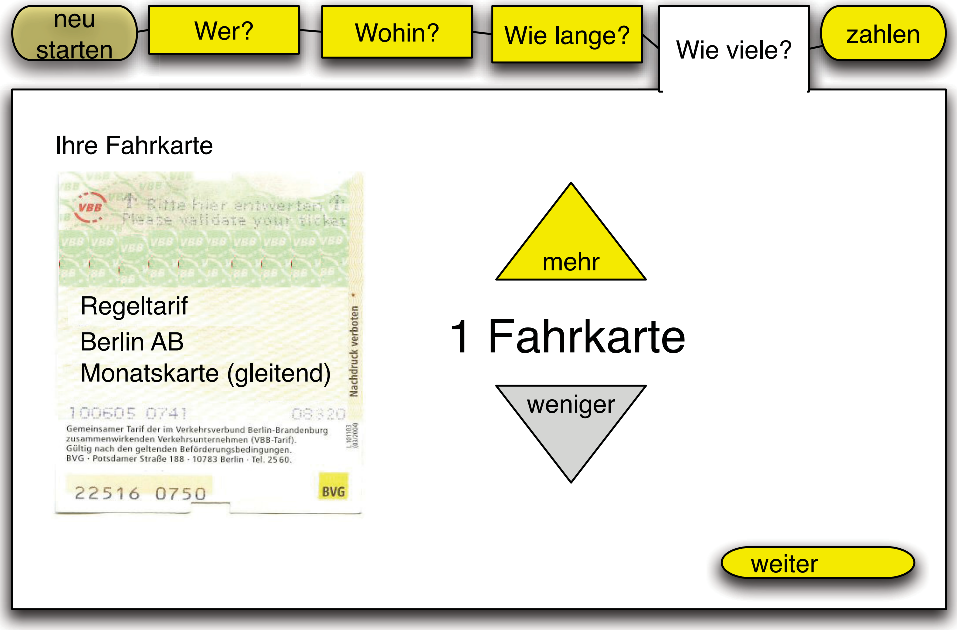
Wie lange?
Wie viele?
zahlen
Ihre Fahrkarte
Regeltarif
Berlin AB
Kurzstrecke
bis 3 Stationen
Einzelfahrschein
bis 2 Stunden
1 Tag
7 Tage
1 Monat
1 Jahr
weiter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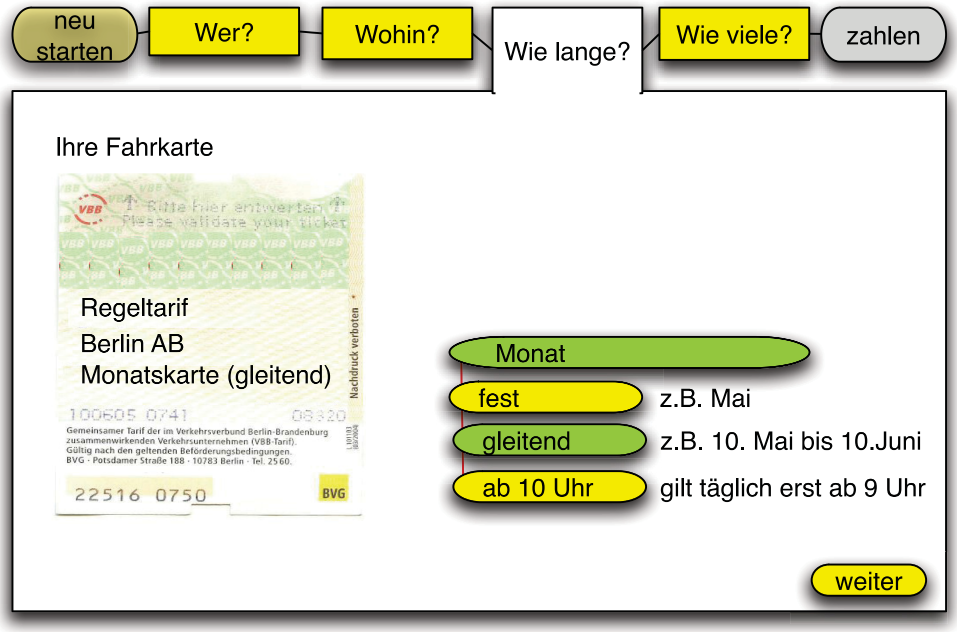
BVG · Potsdamer Straße 188 · 10783 Berlin · Tel. 2560.
22516 0750
BVG
mehr
1 Fahrkarte
weniger
weiter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Gültig nach den geltenden Beförderungsbedingungen.
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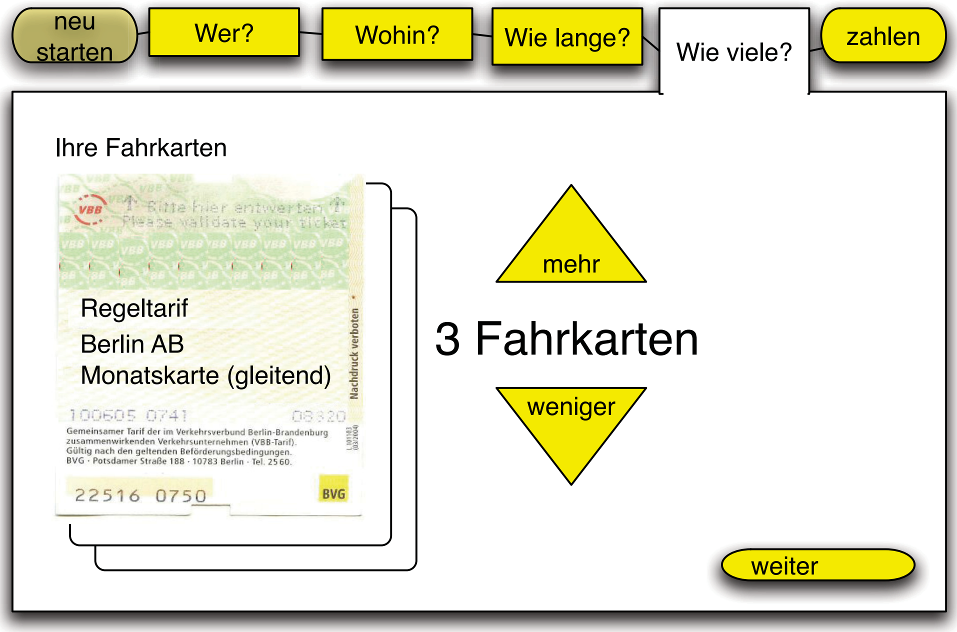
z.B. 10. Mai bis 10.Juni
ab 10 Uhr
gilt täglich erst ab 9 Uhr
weiter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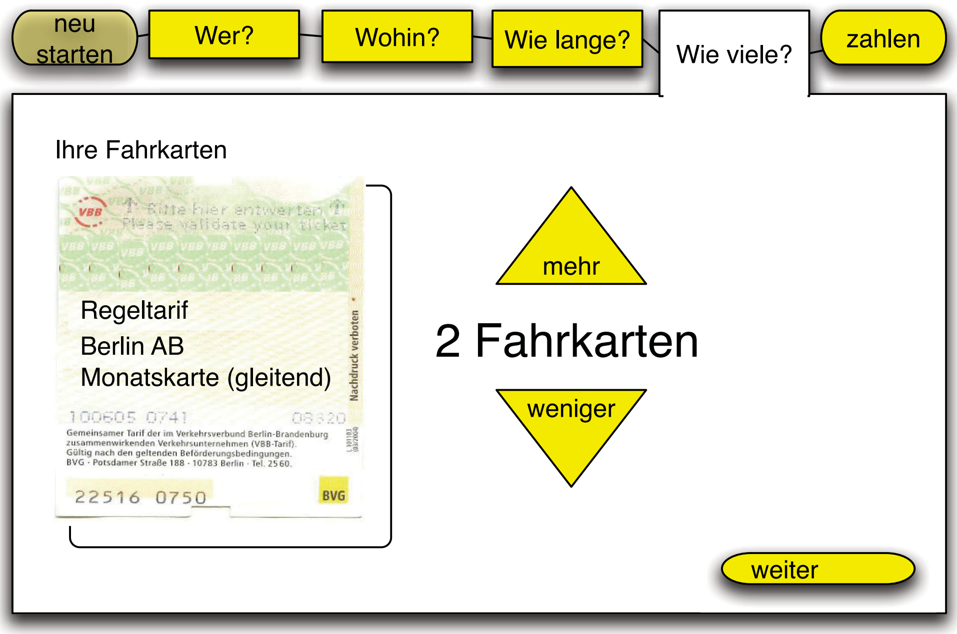
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2 Fahrkarten
weniger
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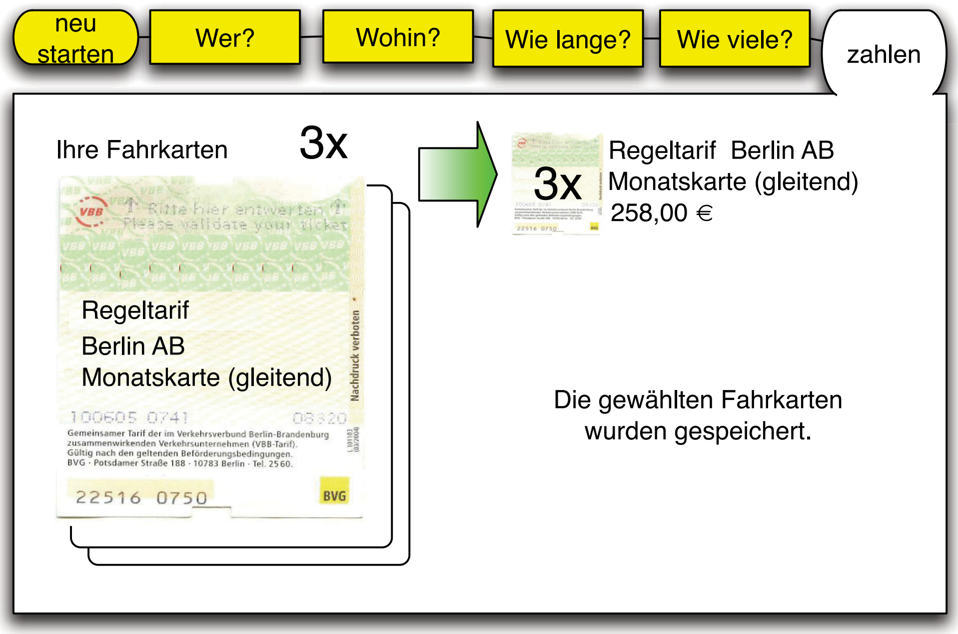

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Wohin?
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zahlen
Ihre Fahrkarten
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Regeltarif
Berlin AB
Monatskarte (gleitend)
22516 0750
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3x
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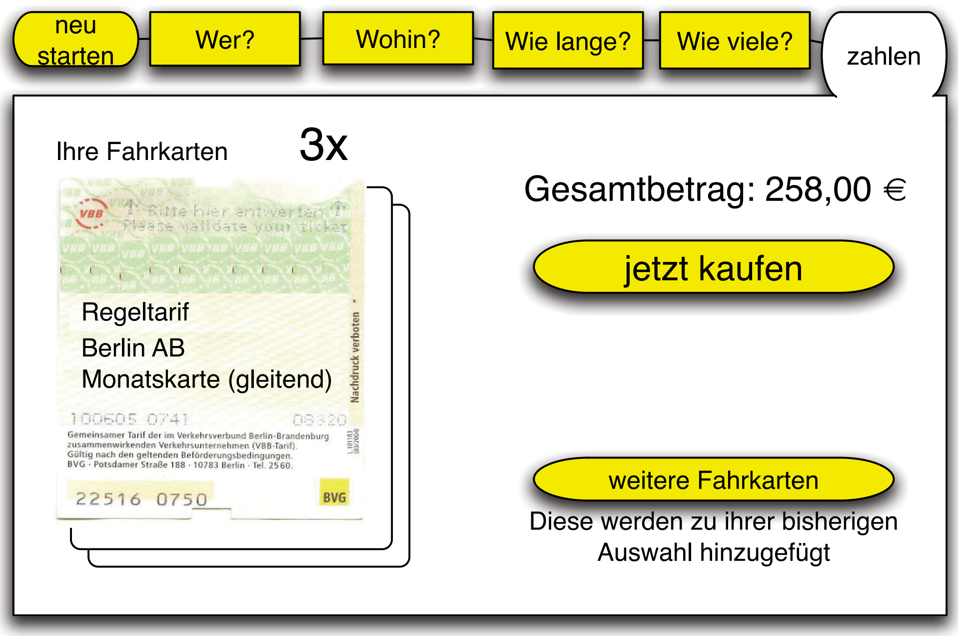
Monatskarte (gleitend)
258,00 €
Die gewählten Fahrkarten
wurden gespeichert.



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zahlen
Ihre Fahrkarten
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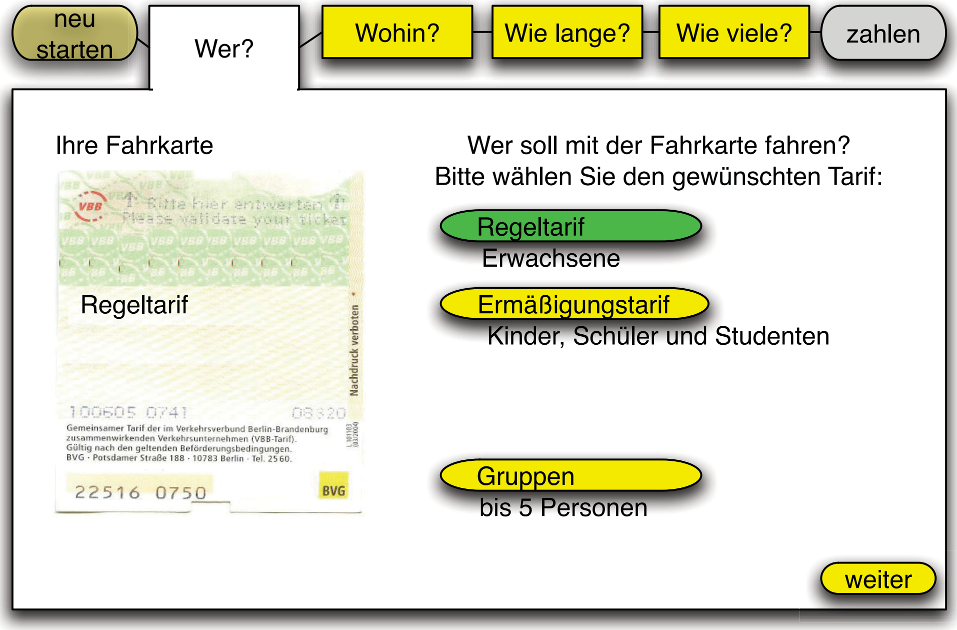
Monatskarte (gleitend)
22516 0750
BVG
Gesamtbetrag: 258,00 €
jetzt kaufen
weitere Fahrkarten
Diese werden zu ihrer bisherigen
Auswahl hinzugefügt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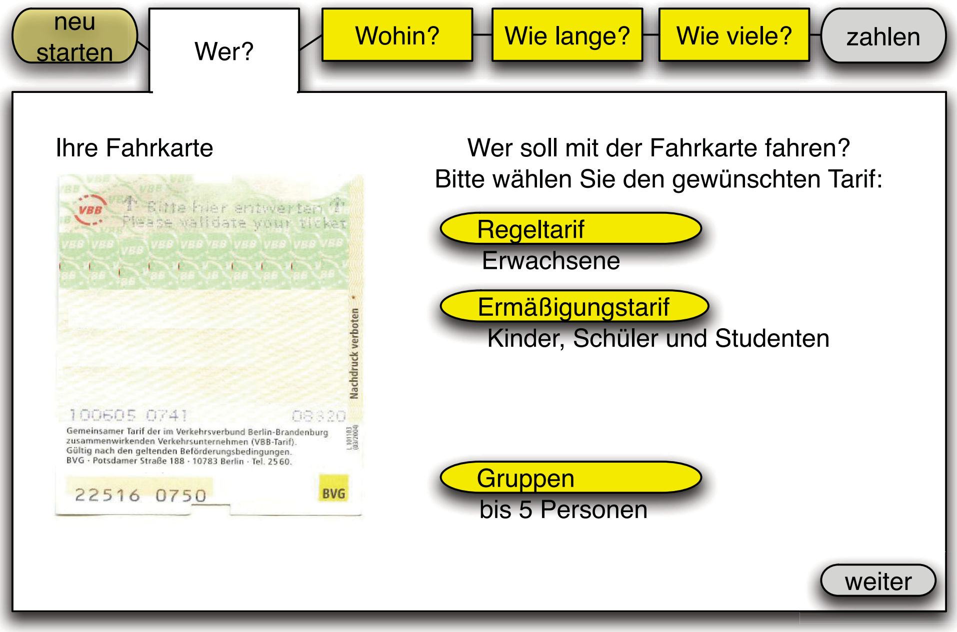
BVG
Wer soll mit der Fahrkarte fahren?
Bitte wählen Sie den gewünschten Tarif:
Regeltarif
Erwachsene
Ermäßigungstarif
Kinder, Schüler und Studenten
Gruppen
bis 5 Personen
weiter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Wer soll mit der Fahrkarte fahren?
Bitte wählen Sie den gewünschten Tarif:
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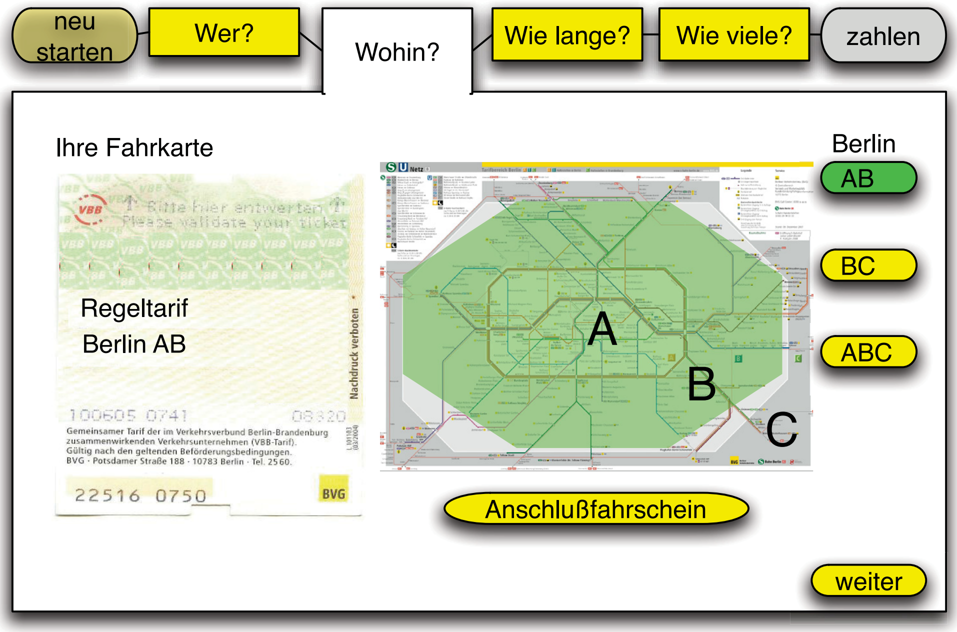
Erwachsene
Ermäßigungstarif
Kinder, Schüler und Studenten
Gruppen
bis 5 Personen
weiter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zahlen
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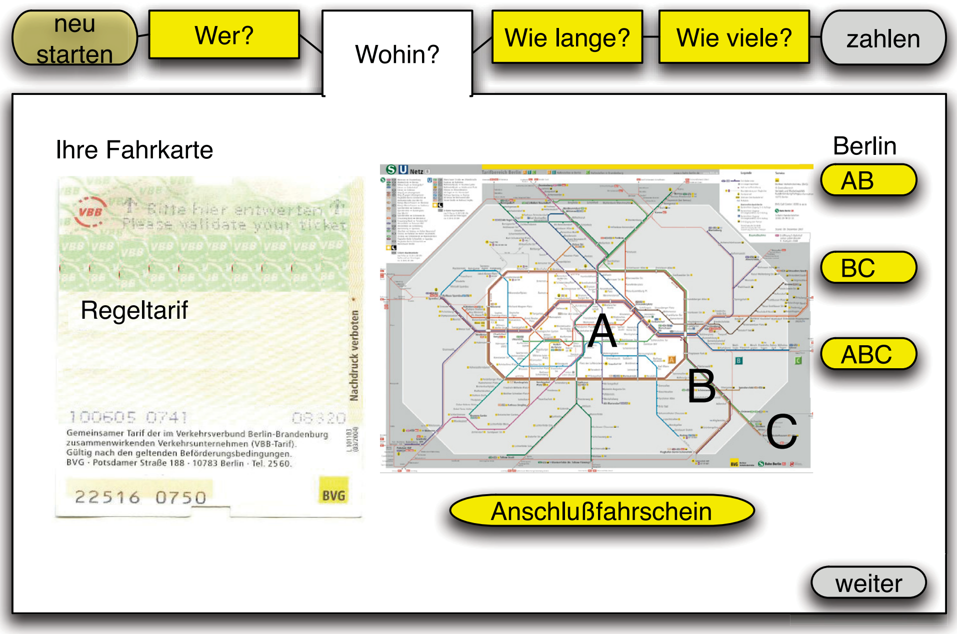
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Wie viele?
zahlen
Ihre Fahrkarte
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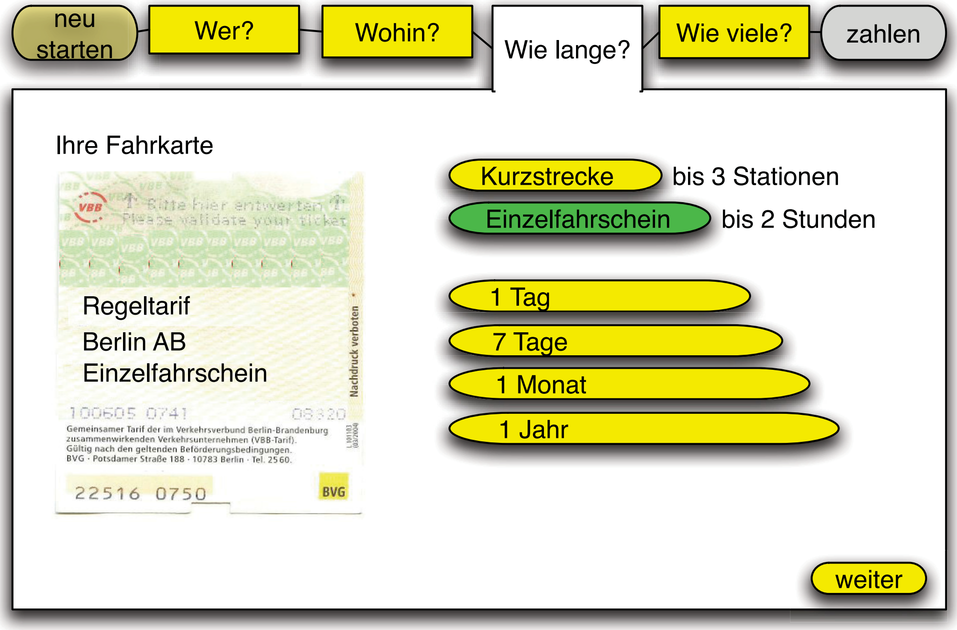
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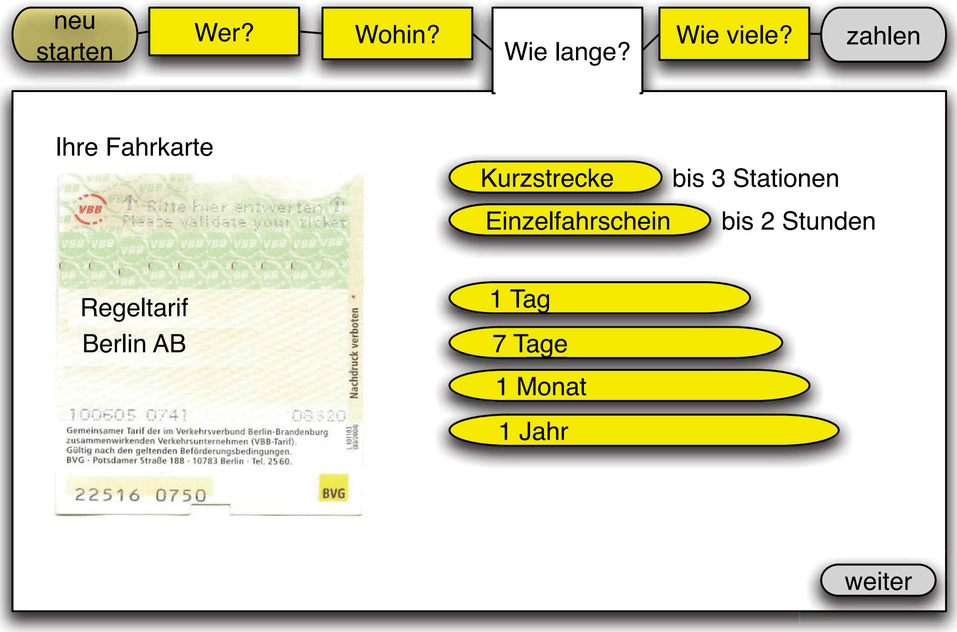
Wie lange?
Wie viele?
zahlen
Ihre Fahrkarte
Regeltarif
Berlin AB
Einzelfahrschein
22516 0750
BVG
Kurzstrecke
bis 3 Stationen
Einzelfahrschein
bis 2 Stunden
1 Tag
7 Tage
1 Monat
1 Jahr
weiter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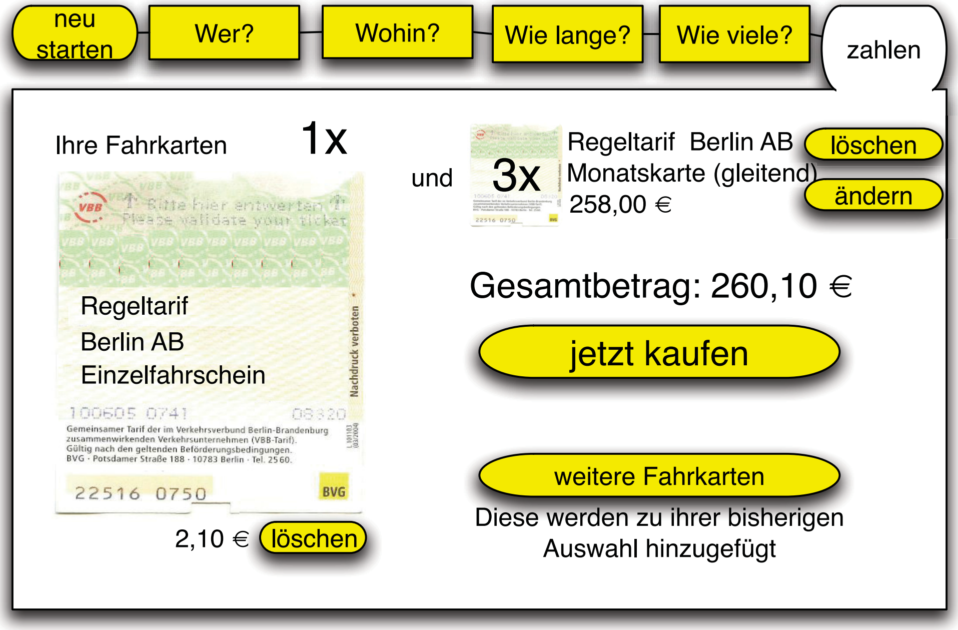
zahlen
Ihre Fahrkarte
Regeltarif
Berlin AB
22516 0750
BVG
Kurzstrecke
bis 3 Stationen
Einzelfahrschein
bis 2 Stunden
1 Tag
7 Tage
1 Monat
1 Jahr
weiter


neu starten
Wer?
Wohin?
Wie lange?
Wie viele?
zahlen
Ihre Fahrkarten
1x
Regeltarif
Berlin AB
Einzelfahrschein
2,10 €
löschen
und
3x
Regeltarif Berlin AB
Monatskarte (gleitend)
258,00 €
löschen
ändern
Gesamtbetrag: 260,10 €
jetzt kaufen
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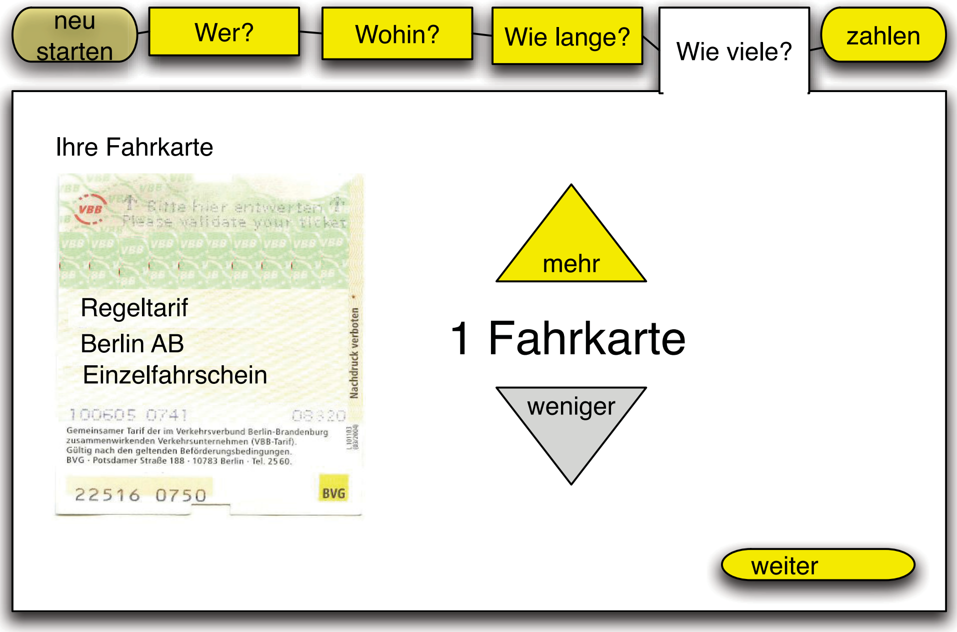
Diese werden zu ihrer bisherigen Auswahl hinzugefügt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Wohin?
Wie lange?
Wie viele?
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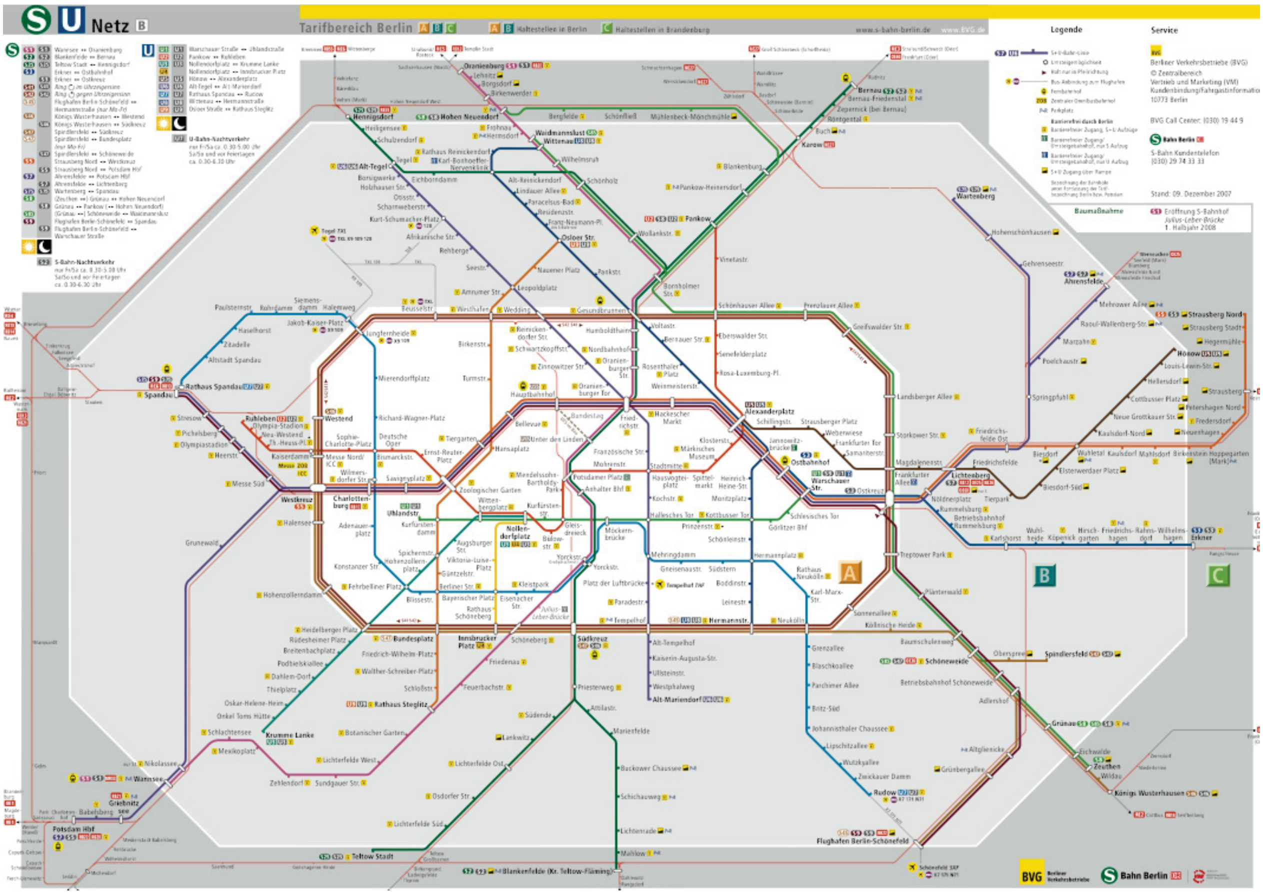
Regeltarif
Berlin AB
Einzelfahrschein
mehr
1 Fahrkarte
weniger
weiter



neu starten | Wer? | Wohin? | Wie lange? | Wie viele? | zahlen

Ihre Fahrkarten 1x

Gesamtbetrag: 2,10 €

jetzt kaufen

weitere Fahrkarten

Diese werden zu ihrer bisherigen Auswahl hinzugefügt

Appendix C
CogTool results (examples)

Appendix D
Computer literacy scale (CLS) manual

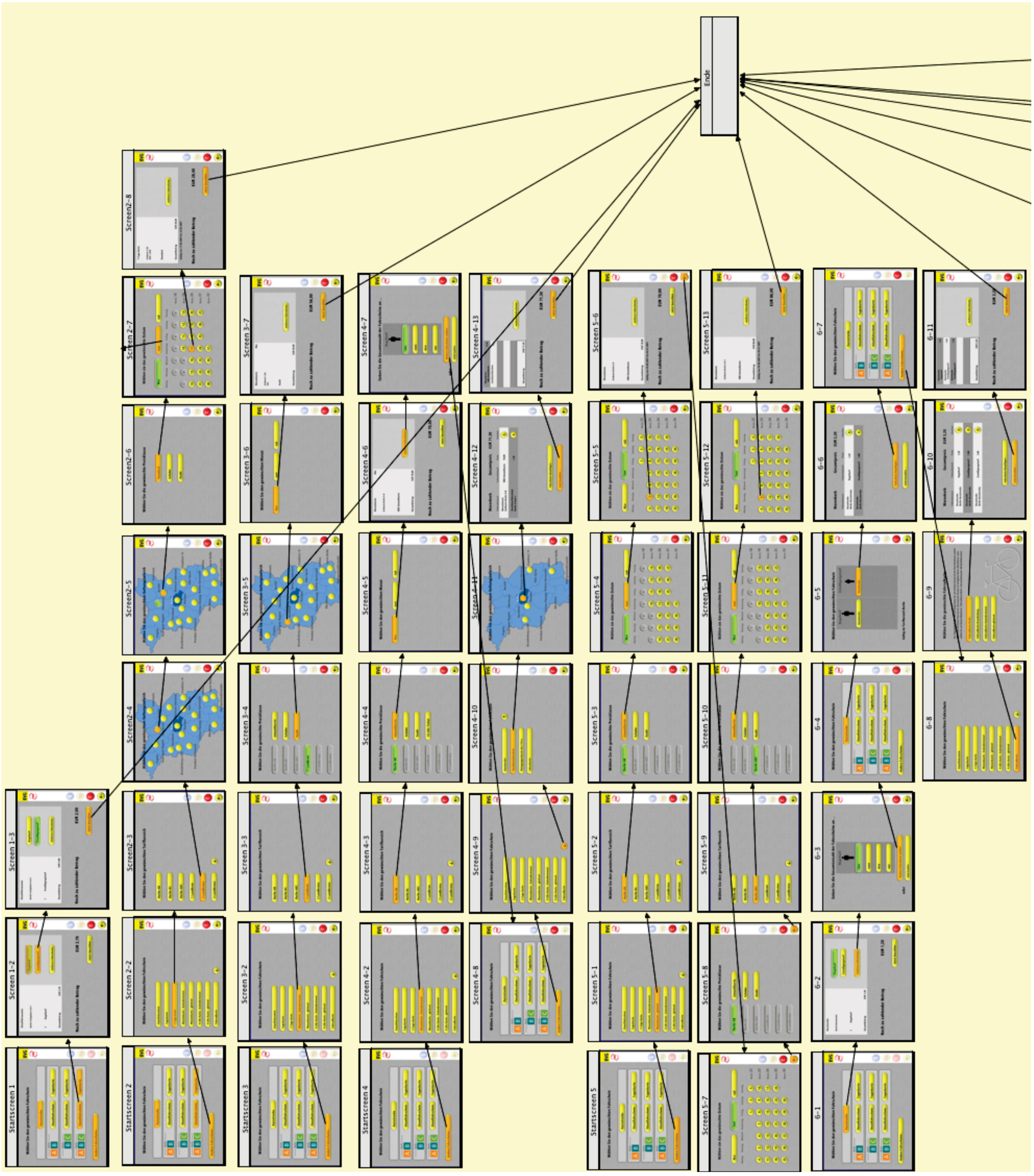


Figure C1. CogTool screenshot for the Original BVG GUI

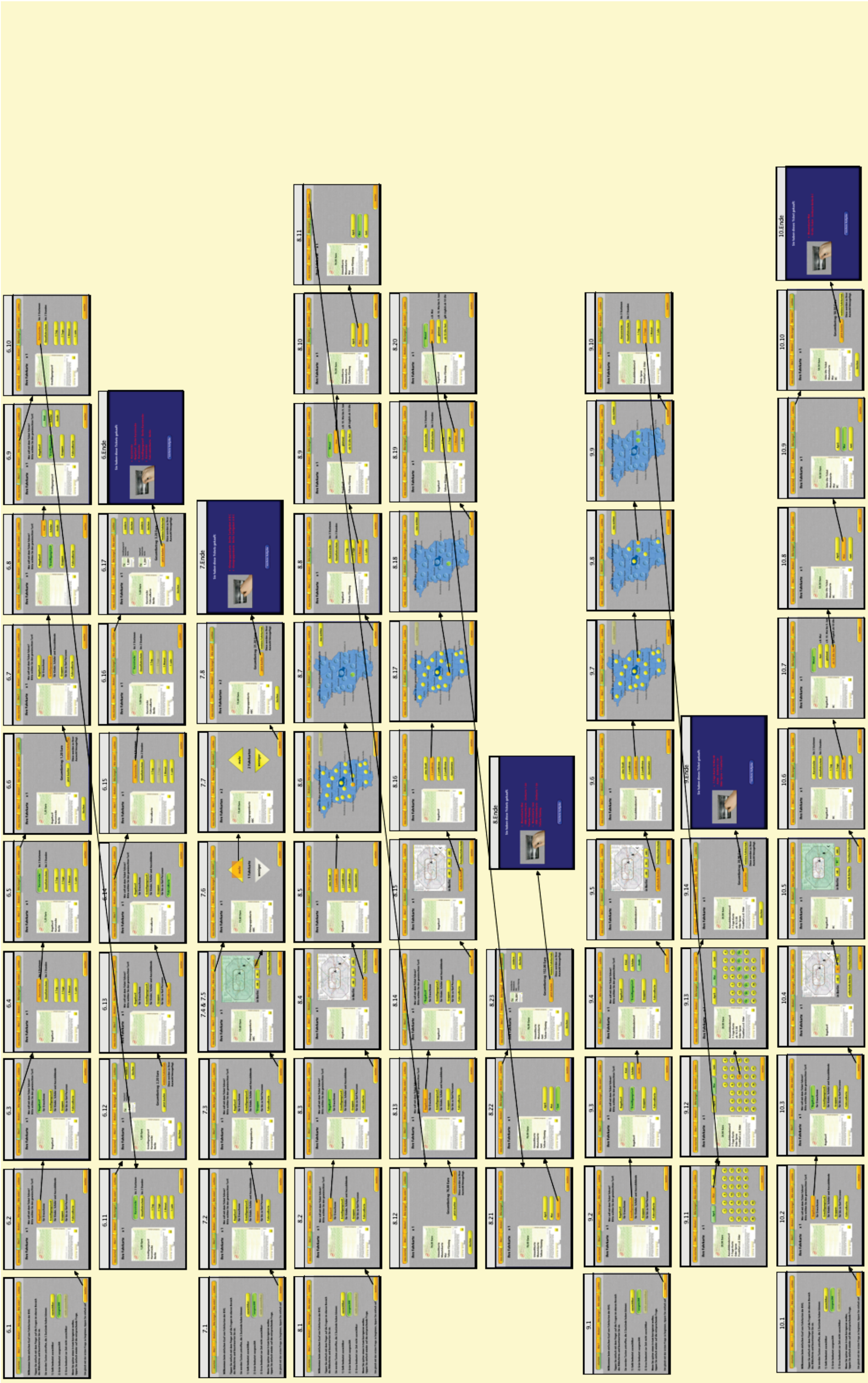


Figure C2. CogTool screenshot for the Wizard GUI

Testhandbuch zum CLS-ST

Kurzbeschreibung des Fragebogens „Computer Literacy Skala - Symbole und Begriffe“

Michael Sengpiel

Kontakt:

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Humboldt-Universität zu Berlin
Institut für Psychologie
Professur Ingenieurpsychologie

www.computer-literacy.net

1 Einführung

Die CLS-ST ist ein objektiver Wissenstest, der ein grundlegendes Verständnis von Symbolen und Begriffen erfasst, die bei der Gestaltung von Computern (GUI) und ähnlichen technischen Geräten häufig eingesetzt werden.

Durch die Beschränkung auf dieses zentrale Merkmal kann mit wenig Zeitaufwand eine gute Vorhersage des allgemeinen Interaktionswissens (Computer Literacy) erfolgen. Da dieses Interaktionswissen im Umgang mit Computern erworben wird, wird dieser zusätzlich erfasst. Durch die Ausrichtung auf die Erfassung des grundlegenden Wissens ist die CLS-ST vor allem für Menschen mit wenig Computer Literacy geeignet, wie sie z.B. unter älteren Menschen (50+) häufig sind. Die Bearbeitungszeit für den CLS-ST liegt bei ca. 10-15 Minuten.

2 Items und Skalen

Der Fragebogen gliedert sich in 2 Teile:

1) Erfahrung mit Computern

Dieser Teil enthält 13 Items, welche die Dauer (1 Item, Jahre Computernutzung), die Intensität (1 Item, Stunden pro Woche Computernutzung) und die Vielfalt (11 Items, 4-stufige Likert-Skala) des Umgangs mit Computern erfragen.

2) Wissen (Symbole und Begriffe)

Dieser Teil enthält 26 Items und 4 Distraktoren, welche das Wissen zu Symbolen (21 Items und 3 Distraktoren) und Begriffen (5 Items und 1 Distraktor) in Form von Zuordnungsaufgaben (matching task) mit numerierten Beschreibungen erfassen.

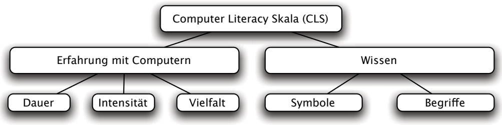


Abbildung 1: Aufbau der Computer Literacy Skala

Berechnung der Skalenwerte

Zur Dateneingabe wird eine SPSS-Eingabemaske zur Verfügung gestellt. In diese können die Angaben der Versuchspersonen der Reihe nach eingetragen werden, wobei die Variablenlabels zusätzlich eine eindeutige Zuordnung ermöglichen. Für die Auswertung der so übertragenen Angaben steht eine einfache SPSS-Syntax zur Verfügung, welche die folgenden Skalenwerte errechnet:

Erfahrung	Variablenname	Werte
Dauer	jcnu	
Intensität	stpw	
Vielfalt	divers_g	0-33
Wissen		
Symbole & Begriffe	cls_ges	0-26

Tabelle 1: Skalenwerte der CLS-ST

Erfahrung

Die Angaben zu Dauer und Intensität der bisherigen Computernutzung können direkt übernommen werden. Für die Vielfalt der Computernutzung gibt es einen Eingabeschlüssel, welcher auch in der SPSS Vorlage unter "Wertelabels" vermerkt ist. Es gilt: nie=0, selten=1, gelegentlich=2, oft=3 und missing=-99. Diese Häufigkeitsangaben werden summiert, woraus sich ein Wertebereich von 0 bis 33 Punkten ergibt.

Wissen

In analoger Weise kann auch mit dem Wissensteil verfahren werden. Die einzelnen Angaben können direkt in die Eingabemaske übernommen werden, wobei die Variablennamen wie folgt zusammengesetzt sind: Der erste Buchstabe steht für Symbol oder Begriff (s oder b), die erste Ziffer steht für den Aufgabenblock (1, 2, 3), die zweite Ziffer steht für das Item (1 bis 7). Das dritte Symbol im zweiten Aufgabenblock hätte entsprechend den Namen: S23.

Jede richtige Antwort wird mit einem Punkt bewertet, woraus sich ein Wertebereich von 0-26 Punkten ergibt. Die SPSS-Syntax zählt die Anzahl richtiger Lösungen zunächst blockweise (s1_ges, s2_ges, s3_ges und b_ges) und summiert diese dann zum Gesamtscore (cls_ges). Die korrekten Lösungen können folgender Tabelle entnommen werden:

Item	1	2	3	4	5	6	7	8
S1	7	5	6	1	0	3	2	4
S2	3	7	5	0	2	4	1	6
S3	7	0	5	3	6	1	2	4
B1	3	5	2	1	4	0		

Tabelle 2: Lösungsschlüssel für Symbole und Begriffe des CLS

Die korrekte Lösung für Item S23 ist demnach „5“. Jeder Aufgaben-Block enthält einen Distraktor, der hier mit „0“ gekennzeichnet ist.

3 Literatur

Sengpiel, M. & Dittberner, D. (2008). The computer literacy scale (CLS) for older adults - development and validation. In M. Herczeg & M. C. Kindsmüller (Hrsg.): Mensch & Computer 2008: Viel Mehr Interaktion. München: Oldenbourg Verlag, S. 7-16

4 Anhang

Der Fragebogen ist im Anhang dieses Handbuchs sowie unter www.computer-literacy.net verfügbar. Zum Einsatz in einer Testbatterie gibt es die CLS auch ohne die Fragen nach Alter und Geschlecht.

VpNr.:

HUMBOLDT-UNIVERSITÄT ZU BERLIN
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT II
KOGNITIVE ERGONOMIE - INGENIEURPSYCHOLOGIE

CLS

Im Folgenden interessiert uns, welche Erfahrungen Sie mit Computern haben. Im ersten Teil dieses Fragebogens bitten wir Sie um einige Angaben zu Ihrer Nutzung von Computern. Im zweiten Teil besteht Ihre Aufgabe darin, Begriffe verschiedenen Symbolen zuzuordnen. Die Bearbeitung wird etwa 10 Minuten dauern. Bitte lesen Sie sich die Erklärung zur Bearbeitung des Fragebogens genau durch. Es ist wichtig, dass Sie alle Fragen beantworten. Vielen Dank für Ihre Unterstützung!

Teil A: Erfahrung mit Computern

1.• Seit wie vielen Jahren benutzen Sie einen Computer? ______

Wenn sie noch nie einen Computer benutzt haben, dann springen Sie bitte direkt zum Teil B!

2.• Wie viele Stunden pro Woche benutzen Sie normalerweise einen Computer? ______

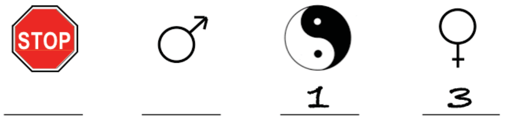
3.• Wie oft nutzen Sie einen Computer für folgende Tätigkeiten?

	nie	**selten**	**gelegent-lich**	**oft**
Textverarbeitung	❒	❒	❒	❒
Tabellenkalkulation	❒	❒	❒	❒
Präsentationserstellung	❒	❒	❒	❒
Bildbearbeitung	❒	❒	❒	❒
Programmieren	❒	❒	❒	❒
Computerspielen	❒	❒	❒	❒
E-Mail	❒	❒	❒	❒
Internet-Surfen	❒	❒	❒	❒
Gezielte Informationssuche	❒	❒	❒	❒
Online-Einkäufe	❒	❒	❒	❒
Online-Banking	❒	❒	❒	❒

Teil B: Zuordnung von Symbolen und Begriffen

Auf der nächsten Seite sehen Sie verschiedene Symbole, die für die Bedienung von technischen Geräten oder Computern relevant sind. Bitte ordnen Sie diese ihren jeweiligen Bedeutungen zu. Zur Veranschaulichung dient dieses Beispiel mit bekannten Alltagssymbolen:

Die Bedeutungen verfügen jeweils über eine Nummer. Diese tragen Sie bitte unter das passende Symbol ein. Bitte beachten Sie dabei, dass es nicht zu jedem Symbol eine passende Bedeutung gibt, sondern immer ein Symbol übrig bleibt.



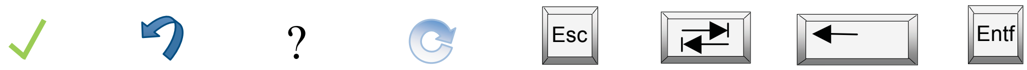
~~(1) Yin-Yang~~ (2) Anhalten ~~(3) weiblich~~

Die Zuordnung wird einfacher, wenn Sie die bereits zugeordneten Bedeutungen einfach durchstreichen.

Es ist nur natürlich, daß Sie nicht alle Antworten kennen. Dennoch bitten wir Sie, <u>alle</u> Bedeutungen möglichst zügig einem Symbol zuzuordnen. Wenn Sie sich nicht sicher sind, raten Sie einfach, welche Bedeutung am besten passen könnte. Sollten Sie noch Fragen haben, steht Ihnen der Versuchsleiter gern zur Seite. Anderenfalls können Sie nun beginnen.

_____ _____ _____ _____ _____ _____ _____ _____

(1) Vorspulen (2) Speichern (3) Anhang (4) Löschen
(5) Abspielen/Start (6) Auswerfen/Eject (7) Ein-/Ausschalter



_____ _____ _____ _____ _____ _____ _____ _____

(1) Löschen/Backspace (2) Abbruch (3) OK/Bestätigen (4) Tabulator
(5) Hilfe (6) Entfernen (7) Rückgängig

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(1) Tabs/Reiter (2) Aktionsknopf/Push Button (3) Objekt vergrößern (4) Rollbalken/Scrollbar
(5) Hintergrundaktivität/Bitte warten (6) Check Boxes/Check Button (7) Cursor/Mauszeiger allgemein

Bitte ordnen Sie nun in gleicher Weise die folgenden Begriffe ihren jeweiligen Erklärungen zu.

Datei	Cancel	Tooltip	Browser	Hyperlink	Icon
_____	_____	_____	_____	_____	_____

(1) Anwendung zum Betrachten von Inhalten im WWW (World Wide Web)
(2) Kurzer Text, der eingeblendet werden kann, wenn der Mauszeiger längere Zeit auf einem Icon verweilt
(3) Daten, die als eigenständiges Dokument unter einem gemeinsamen Namen abgelegt werden
(4) Querverweise in Hypertext-Dokumenten, die zu anderen Stellen/Seiten verzweigen
(5) Abbrechen

Vielen Dank für das Ausfüllen des Fragebogens!

Bitte notieren Sie abschließend Ihr Alter und Geschlecht. Danke!	Alter	Geschlecht
	_____	❐ weiblich ❐ männlich

Appendix E
Tables

Table E1

Mean differences between experimental groups (age x condition), with 5x4 comparisons that are of particular interest for the usefulness of the interventions marked C1, C2 & C3 and for universal usability marked C4 & C5

Pairwise Comparisons in		effectiveness		efficiency (time)		efficiency (steps)		satisfaction	
I	J	Mean I-J	p=	Mean I-J	p=	Mean I-J	p=	Mean I-J	p=
young control	old control	31.92***	0.000	19.04***	0.000	26.33***	0.000	15.59*	0.039
	young video	-6.32		-5.93		-3.10		-1.59	
C4 →	old video	5.55		12.24***	0.000	6.24		7.88	
	young wizard	-2.27		9.41**	0.001	20.30***	0.000	-0.26	
C5 →	old wizard	-3.18		18.96***	0.000	21.15***	0.000	-4.44	
old control	young control	-31.92***	0.000	-19.04***	0.000	-26.33***	0.000	-15.59*	0.039
	young video	-38.24***	0.000	-24.98***	0.000	-29.43***	0.000	-17.18*	0.012
C1 →	old video	-26.37***	0.000	-6.80		-20.09***	0.000	-7.71	
	young wizard	-34.19***	0.000	-9.64**	0.001	-6.04		-15.85*	0.033
C2 →	old wizard	-35.10***	0.000	-0.08		-5.18		-20.03**	0.002
young video	young control	6.32		5.93		3.10		1.59	
	old control	38.24***	0.000	24.98***	0.000	29.43***	0.000	17.18*	0.012
	old video	11.87		18.18***	0.000	9.35		9.47	
	young wizard	4.05		15.34***	0.000	23.40***	0.000	1.34	
	old wizard	3.14		24.90***	0.000	24.26***	0.000	-2.85	
old video	young control	-5.55		-12.24***	0.000	-6.24		-7.88	
	old control	26.37***	0.000	6.80		20.09***	0.000	7.71	
	young video	-11.87		-18.18***	0.000	-9.35		-9.47	
	young wizard	-7.82		-2.84		14.05*	0.014	-8.14	
C3 →	old wizard	-8.73		6.72*	0.044	14.91**	0.007	-12.32	
young wizard	young control	2.27		-9.41**	0.001	-20.30***	0.000	0.26	
	old control	34.19***	0.000	9.64**	0.001	6.04		15.85*	0.033
	young video	-4.05		-15.34***	0.000	-23.40***	0.000	-1.34	
	old video	7.82		2.84		-14.05*	0.014	8.14	
	old wizard	-0.91		9.56***	0.000	0.86		-4.19	
old wizard	young control	3.18		-18.96***	0.000	-21.15***	0.000	4.44	
	old control	35.10***	0.000	0.08		5.18		20.03**	0.002
	young video	-3.14		-24.90***	0.000	-24.26***	0.000	2.85	
	old video	8.73		-6.72*	0.044	-14.91**	0.007	12.32	
	young wizard	0.91		-9.56***	0.000	-0.86		4.19	

Based on estimated marginal means, * mean differences are significant at *p<.05, **p<.01, ***p<.001

Table E2

5x4 selected pairwise comparisons for effectiveness, efficiency (time and steps) and satisfaction, integrating the results from MANOVA / ANOVAs and corresponding non parametric Kruskal-Wallis test with Mann-Whitney U-tests and hypotheses H4-17 with the expected relation (< = >) and index of confirmation (H^+ = confirmed by parametric and non-parametric tests, $H^/$ = confirmed by parametric or non-parametric tests, H^- = not confirmed)

↓ Hypotheses & relation		↓		Mean	MANOVA	non parametric		Mann-	Asymp.	effect
	I		J	Differences	/ ANOVA	Kruskal-Wallis		Whitney	(2-tailed)	size
	effectiveness			(I-J)	p* =	Sig.	Adj. Sig.	U	Sig.	r
H4$^+$	old control	<	old video	-26.369*	0.000	0.005	0.071	85.500	0.001*	-0.51
H5$^+$		<	old wizard	-35.101*	0.000	0.000	0.000	47.000	0.000*	-0.68
H6$^-$	old video	<	old wizard	-8.732				142.500	0.072	-0.28
H7$^+$	young control	=	old video	5.55				168.000	0.264	-0.17
H8$^+$		=	old wizard	-3.182				197.000	0.542	-0.09
	efficiency (steps)									
H9$^+$	old control	<	old video	-20.089*	0.000	0.001	0.010	83.000	0.001*	-0.52
			old wizard	-5.178				177.000	0.274	-0.17
H10$^+$	old video	>	old wizard	14.911*	0.007	0.002	0.034	76.000	0.000*	-0.55
	young control		old video	6.243				145.000	0.090	-0.26
			old wizard	21.154*	0.000	0.000	0.000	60.000	0.000*	-0.62
	efficiency (time)									
H11$^/$	old control	<	old video	-6.803		0.011	0.170	89.000	0.002*	-0.49
			old wizard	-0.082				184.000	0.359	-0.14
H12$^+$	old video	>	old wizard	6.721*	0.044	0.012	0.178	59.000	0.000*	-0.62
H13$^+$	young control	>	old video	12.240*	0.000	0.003	0.041	67.000	0.000*	-0.58
H14$^+$		>	old wizard	18.961*	0.000	0.000	0.000	7.000	0.000*	-0.83
	satisfaction									
H15$^-$	old control	<	old video	-7.71				151.500	0.553	-0.10
H16$^/$		<	old wizard	-20.033*	0.002			94.000	0.012	-0.41
H17$^-$	old video	<	old wizard	-12.323				109.000	0.023	-0.36
	young control		old video	7.879				150.000	0.261	-0.18
			old wizard	-4.444				152.500	0.198	-0.20

Based on estimated marginal means, * significance values with Bonferroni adjustment for multiple comparisons
Each row tests the null hypothesis that distributions for I and J are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05, values above .05 not shown.
For Mann-Whitney U-tests, all values for the test statistic U, uncorrected significance and effect size r are shown.

Table E3

Five main categories summarizing participants' reasons for avoiding ticket vending machines (in German)

Simplicity: 21x ticket office is simpler / TVM too complicated	
einfacher am Schalter	Bedienung einfacher
einfacher, schneller, persönlicher Kontakt	schneller, einfacher
einfacher	zu kompliziert
unkomplizierter	ist kompliziert
unkompliziert, Vertrauen am Schalter größer, Geld hinzulegen	bequemer, einfacher
einfacher am Schalter	einfacher, persönlicher
einfacher Dienstleistung zu nutzen	simpler, menschlicher
einfacher am Schalter, die gewünschte FK zu kaufen	einfacher, menschlicher
einfacher, Fahrscheinautomat kompliziert, Schlange macht nervös	zu mühsam, lästig
keine Nerven, zu kompliziert	dauert zu lange, lästig
einfacher, man wird bedient	
Personal contact: 16x prefer personal contact at the ticket office	
Personen am Schalter, Automat unpersönlich, klappt nicht	persönlicher
persönlicher Kontakt, zu kompliziert	persönlicher
komplette Bedienung durch Person, fehlende Kommuniktion	persönlicher Kontakt
persönlicher Kontakt, nur wenn keine Schlange vor Schalter	besser Kontkt zu personl
Beratung am Schalter, Rabatt	persönlicher
persönlicher, Auskunft zusätzlich	Gespräch, persönlicher Kontakt
persönliches Gespräch, z.B. Informationen über Umsteigen, Verspätungen	persönlicher Kontakt mit Personal
lebend lieber als Maschine, lieber unterhalten	persönlicher, Automat schwieriger
Flexibility: 10x better information to get the ticket I need, especially for unusual cases, more tolerance for mistakes	
Nachfrage für z.B. weitere Verbindungen/Anschluß, Ansprechpartner, geht am Schlter schneller	bessere Auskunft
verständlicher, Fragen mögllich, keine Beziehungsängste zu Angestellten am Schalter	Beratung besser
Sonderwünsche, persönlicher Bezug, Unsicherheit reduzieren	passendes Fahrgeld, zu umständlich
konkreter, nicht so fehleranfällig, wechselgeld beim automaten manchmal nicht vorhanden	Touristen blockieren den Automten
einfacher, Angestellter muss sich mit meinen individuellen Wünschen auseinandersetzen	bequemer
Safety: 4x safer, afraid to make mistakes	
Sicherheit	sicherer
unvertraut, Angst Fehler zu machen	unsicher
Reliability: 4x TVMs do not work properly or I don't know how to use them, eg. I cannot read the screen, TVM takes too long or is out of order	
Fahrscheinautomaten sind fehleranfällig, oft nicht betriebsfähig, zerstört oder mit Farbe unkenntlich / beschmiert	weiß nicht wie die funktionieren, bräuchte jemanden der sie mir erklärt
man kann nichts auf d. Bildschirm erkennen (es blendet, Sichtfeld zerkratzt)	Funktioniert nie, Ich rege mich schnell auf, dauert zu lang

Table E4
Eleven tasks every participant was asked to complete with the simulated ticket vending machine

task	English translation	German original
0	Please purchase a single regular ticket for the fare zone Berlin AB. (practice)	Bitte kaufen Sie einen Einzelfahrschein für das Tarifgebiet Berlin AB Regeltarif. (Übung)
1	Please purchase a single reduced fare ticket for the fare zone Berlin ABC.	Bitte kaufen Sie einen Einzelfahrschein für das Tarifgebiet Berlin ABC Ermäßigungstarif.
2	Please purchase a 7 day ticket regular fare for the county of Oberhavel and Barnim. The 7 day ticket should be valid starting May 3rd.	Bitte kaufen Sie eine 7-Tage-Karte für die Landkreise Oberhavel und Barnim, ohne Ermäßigung (Standard). Die 7-Tage-Karte soll ab dem 03. Mai gültig sein.
3	Please purchase a monthly ticket for the month of May. You want the reduced fare "Azubi" for the county Havelland.	Bitte kaufen Sie eine Monatskarte für den Monat Mai. Sie möchten den Ermäßigungstarif Azubi für den Landkreis Havelland.
4	Please purchase a monthly ticket for the month of May for the fare zone Berlin AB, regular fare (Environmental ticket). Additionally, please purchase a connecting ticket for the fare zone C. Important: Please purchase both tickets in a single process, so that you can pay for both at once.	Bitte kaufen Sie eine Monatskarte für den Monat Mai für das Tarifgebiet Berlin AB ohne Ermäßigung (Umweltkarte). Zusätzlich kaufen Sie bitte einen Anschlussfahrschein C. Wichtig: Kaufen Sie bitte beide Fahrscheine in einem Kaufvorgang, so dass Sie sie zusammen bezahlen können!
5	Part 1: Please purchase a gliding monthly ticket for the fare zone Berlin AB, regular fare, valid starting May 5th. Do not pay yet, but solve the second part of the task first. Part 2: You notice that you have chosen the wrong fare zone - instead of AB you want to get ABC. Now, please purchase a gliding monthly ticket for the fare zone Berlin ABC, regular fare, valid starting May 5th.	Teil 1: Kaufen Sie bitte eine Monatskarte-gleitend für das Tarifgebiet Berlin AB, ohne Ermäßigung, ab dem 5. Mai. Bezahlen Sie diesmal aber noch nicht, sondern lösen Sie bitte erst Teil 2 der Aufgabe. Teil 2: Ihnen fällt ein, dass Sie das falsche Tarifgebiet gewählt haben, statt AB, möchten Sie ABC kaufen. Bitte kaufen Sie nun eine Monatskarte-gleitend für das Tarifgebiet Berlin ABC, ohne Ermäßigung, ab dem 5. Mai.
6	Please purchase a short range ticket for yourself (regular fare), your child (reduced fare) and your bicycle in a single process.	Kaufen Sie bitte jeweils eine Kurzstreckenkarte für sich (Regeltarif), Ihr Kind (Ermäßigt) und Ihr Fahrrad in einem Kaufvorgang.
7	You are travelling with friends and need 2 small group tickets for Berlin fare zone ABC. Please purchase them in a single process.	Sie sind mit Freunden unterwegs und benötigen 2 Kleingruppenkarten für Berlin ABC. Bitte kaufen Sie die Fahrscheine in einem Kaufvorgang.
8	Please purchase in a single process 2 monthly tickets (Environmental ticket) for the county Teltow Fläming - One valid for May and the other for June.	Bitte kaufen Sie in einem Kaufvorgang 2 Monatskarten (Umweltkarte) für den Landkreis Teltow Fläming. Eine Monatskarte soll für Mai und die andere für Juni gelten.
9	An apprentice needs a ticket for the counties of Oder-Spree and Frankfurt/Oder starting May 16th. The ticket should be valid for one week. Please purchase the ticket for him.	Ein Auszubildender benötigt ab dem 16. Mai einen Fahrschein für die Landkreise Oder-Spree und Frankfurt/Oder. Die Karte soll eine Woche gelten. Bitte kaufen Sie ihm den Fahrschein.
10	Please purchase a ticket for the month of May for the fare zones B and C. You do not need to use the ticket before 10.00 o'clock.	Bitte kaufen Sie einen Fahrschein für den Monat Mai für den Tarifbereich B und C. Ihnen reicht es, nach 10:00 Uhr loszufahren.
11	A student needs a monthly ticket for the entire fare zone of Berlin/Brandenburg starting June 25th. Please purchase the ticket for him.	Ein Schüler benötigt ab dem 25. Juni eine Monatskarte für den gesamten Tarifbereich Berlin/Brandenburg. Bitte kaufen Sie ihm den Fahrschein.

Table E5

Minimum number of necessary steps to solve the eleven tasks

Task	1	2	3	4	5	6	7	8	9	10	11	Total	Mean
Original	3	9	7	13	13	11	8	14	9	6	8	101	9.2
Wizard	9	9	13	16	14	17	8	23	14	10	13	146	13.3

Table E6

CogTool-estimated skilled user time estimates to solve the eleven tasks in seconds

Task	1	2	3	4	5	6	7	8	9	10	11	Total	Mean
Original CogTool	5	15	12	22	23	18	13	24	15	10	13	172	16
Wizard CogTool	16	22	23	28	24	29	14	40	24	17	22	260	24

Table E7

Mean number of solved tasks for all groups

group	1	2	3	4	5	6	7	8	9	10	11	Total	Mean	F*
young control	1.0	0.8	0.9	0.7	1.0	0.8	1.0	1.0	0.8	0.9	0.6	9.3	0.84	
old control	0.7	0.5	0.8	0.3	0.6	0.5	0.6	0.4	0.5	0.6	0.2	5.8	0.52	0.62
young video	1.0	1.0	0.9	0.8	1.0	0.9	1.0	1.0	1.0	1.0	0.8	10.1	0.92	
old video	0.9	0.8	1.0	0.6	0.9	0.7	0.9	0.7	0.9	1.0	0.7	8.8	0.80	0.87
young wizard	0.8	0.8	0.9	0.8	1.0	0.9	1.0	0.9	0.9	0.9	0.9	9.7	0.88	
old wizard	1.0	0.9	1.0	0.7	0.9	0.9	0.9	0.9	0.9	0.9	1.0	9.7	0.88	1.00

*F= ratio factor between Mean number of solved tasks between age groups in the same experimental condition

Table E8

Mean number of steps needed to solve the eleven tasks for all groups, with the ideal minimum number of steps for comparison

group	1	2	3	4	5	6	7	8	9	10	11	Total	Mean	F1*	F2**
Original (ideal)	3	9	7	13	13	11	8	14	9	6	8	101	9		
young control	3	11	8	20	15	13	9	17	11	11	17	135	12	1.33	
old control	3	11	9	24	16	20	9	22	11	13	15	154	14	1.55	1.16
young video	4	14	8	21	18	15	10	17	11	13	12	143	13	1.44	
old video	3	12	8	20	14	20	10	22	11	9	15	143	13	1.44	1.00
Wizard (ideal)	9	9	13	16	14	17	8	23	14	10	13	146	13		
young wizard	11	19	15	27	18	25	10	29	18	13	16	202	18	1.38	
old wizard	13	18	16	23	20	27	10	30	18	13	19	206	19	1.46	1.05

* F1= ratio factor between Mean number of necessary steps (ideal) and actual steps needed

** F2= ratio factor between Mean steps needed by age groups in the same experimental condition

Table E9

Mean times needed to solve the eleven tasks in seconds for all groups, with CogTool skilled user time estimates for comparison

group	1	2	3	4	5	6	7	8	9	10	11	Total	Mean	F1*	F2**
Original (CogTool)	5	15	12	22	23	18	13	24	15	10	13	172	16		
young control	16	58	40	107	73	65	42	68	51	64	59	643	58	3.63	
old control	35	106	74	253	181	212	67	151	119	129	104	1432	130	8.13	2.24
young video	14	62	32	100	73	66	34	54	38	41	42	556	51	3.19	
old video	24	90	63	177	119	186	56	162	86	82	103	1148	104	6.50	2.04
Wizard (CogTool)	16	22	23	28	24	29	14	40	24	17	22	260	24		
young wizard	65	121	70	161	96	108	43	109	71	68	78	990	90	3.75	
old wizard	143	209	143	288	264	225	89	237	140	114	156	2009	183	7.63	2.03

* F1= ratio factor between Means of CogTool estimated skilled user time and actual time needed

**F2= ratio factor between Mean time needed by age groups in the same experimental condition

Table E10

Interpretation of effect sizes for omega squared according to Kirk (1996), p.751

ω^2	interpretation
.010	small effect
.059	medium effect
.138	large effect

Table E11

Sample sizes, means and standard deviations in dependent variables (effectiveness, efficiency (time), efficiency (steps) and satisfaction) for all groups

DV	age group	exp. condition	Mean	SD	N
effectiveness					
	young	control	85.45	15.15	20
		video	91.77	9.05	21
		wizard	87.73	12.95	20
		total	88.38	12.65	61
	old	control	53.54	26.98	18
		video	79.90	15.62	19
		wizard	88.64	11.75	20
		total	74.64	23.85	57
	total	control	70.33	26.71	38
		video	86.14	13.81	40
		wizard	88.18	12.21	40
		total	81.74	20.05	118
efficiency (time)					
	young	control	27.88	10.19	20
		video	33.82	7.53	21
		wizard	18.48	6.63	20
		total	26.84	10.32	61
	old	control	8.84	5.92	18
		video	15.64	6.18	19
		wizard	8.92	2.47	20
		total	11.13	5.94	57
	total	control	18.86	12.74	38
		video	25.18	11.45	40
		wizard	13.70	6.91	40
		total	19.25	11.56	118
efficiency (steps)					
	young	control	64.73	14.39	20
		video	67.83	11.24	21
		wizard	44.43	8.76	20
		total	59.14	15.52	61
	old	control	38.39	19.36	18
		video	58.48	13.32	19
		wizard	43.57	7.72	20
		total	46.91	16.24	57
	total	control	52.25	21.36	38
		video	63.39	13.00	40
		wizard	44.00	8.16	40
		total	53.23	16.96	118
satisfaction					
	young	control	80.21	8.57	20
		video	81.81	8.11	21
		wizard	80.47	10.93	20
		total	80.85	9.14	61
	old	control	64.62	26.85	18
		video	72.33	18.79	19
		wizard	84.66	13.59	20
		total	74.22	21.56	57
	total	control	72.83	20.77	38
		video	77.31	14.82	40
		wizard	82.56	12.36	40
		total	77.65	16.62	118

Table E12

Mean ranks in effectiveness, efficiency (time and steps) and satisfaction across experimental groups

		effectiveness		efficiency (time)		efficiency (steps)		satisfaction
experimental group	N	Mean Rank	N	Mean Rank	N	Mean Rank	N	Mean Rank
young control	21	66.88	21	89.76	21	86.71	20	59.95
old control	21	24.21	21	27.67	21	35.76	18	44.22
young video	21	82.12	21	105.62	21	95.00	21	64.98
old video	20	55.25	20	56.10	20	73.90	19	48.61
young wizard	20	73.55	20	67.95	20	43.60	20	62.30
old wizard	21	73.17	21	27.86	21	39.67	20	74.60
Total	124		124		124		118	

Table E13

results of the Mann-Whitney U-test for the five selected comparisons

(1) old control vs. old video	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
Mann-Whitney U	85.500	89.000	83.000	151.500
Z	-3.276	-3.156	-3.312	-0.593
N	41	41	41	37
effect size r	-0.51	-0.49	-0.52	-0.10
Asymp. Sig. (2-tailed)	0.001*	0.002*	0.001*	0.553
(2) old control vs. old wizard	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
Mann-Whitney U	47.000	184.000	177.000	94.000
Z	-4.416	-0.918	-1.094	-2.516
N	42	42	42	38
effect size r	-0.68	-0.14	-0.17	-0.41
Asymp. Sig. (2-tailed)	0.000*	0.359	0.274	0.012
(3) old video vs. old wizard	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
Mann-Whitney U	142.500	59.000	76.000	109.000
Z	-1.800	-3.938	-3.495	-2.277
N	41	41	41	39
effect size r	-0.28	-0.62	-0.55	-0.36
Asymp. Sig. (2-tailed)	0.072	0.000*	0.000*	0.023
(4) young control vs. old video	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
Mann-Whitney U	168.000	67.000	145.000	150.000
Z	-1.117	-3.730	-1.695	-1.125
N	41	41	41	39
effect size r	-0.17	-0.58	-0.26	-0.18
Asymp. Sig. (2-tailed)	0.264	0.000*	0.090	0.261
(5) young control vs. old wizard	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
Mann-Whitney U	197.000	7.000	60.000	152.500
Z	-0.610	-5.371	-4.037	-1.287
N	42	42	42	40
effect size r	-0.09	-0.83	-0.62	-0.20
Asymp. Sig. (2-tailed)	0.542	0.000*	0.000*	0.198

* values significant at α=.0025 with Bonferroni adjustment for 20 comparisons

Table E14

Attitude toward ticket vending machines mean scores of older and younger participant groups

age group	young			old		
attitude items	Mean	N	SD	Mean	N	SD
repulsive - appealing	0.35	62	1.32	-0.37	59	1.53
unpleasant - pleasant	0.31	62	1.14	-0.65	60	1.40
frustrating - encouraging	0.53	62	1.04	-0.42	59	1.68
complicated - simple	1.55	62	1.40	-0.75	61	1.63
unclear - clear	1.19	62	1.29	-0.35	60	1.54
useless - useful	2.40	62	0.86	0.92	60	1.81
inappropriate - appropriate	2.39	62	0.71	1.10	61	1.67
difficult to learn - easy to learn	1.73	62	1.04	0.02	60	1.57

Table E15

Pearson correlations of mental effort (RSME mean scores) and effectiveness, efficiency and satisfaction (dependent variables) for all experimental groups

group	effectiveness	efficiency (time)	efficiency (steps)	satisfaction
overall	-.387**	-.364**	-.309**	-.514**
	(-.58, -.16)	(-.51, -.22)	(-.47, -.12)	(-.68, -.31)
young	-.362**	-.126	-.187	-.594**
	(-.53, -.09)	(-.34, .12)	(-.40, .08)	(-.75, -.39)
old	-.291*	-.352**	-.243	-.461**
	(-.54, .03)	(-.54, -.15)	(-.47, .01)	(-.69, -.17)
young control	-.641**	-.200	-.490*	-.313
	(-.86, -.13)	(-.54, .37)	(-.75, .07)	(-.69, .25)
old control	-.290	-.399	-.306	-.614**
	(-.70, .19)	(-.76, .09)	(-.69, .16)	(-.88, -.25)
young video	.159	.245	.226	-.721**
	(-.28, .62)	(-.06, .62)	(-.15, .65)	(-.90, -.29)
old video	.205	.019	.253	.104
	(-.31, .67)	(-.33, .58)	(-.15, .62)	(-.35, .42)
young wizard	-.384	-.466*	-.496*	-.706**
	(-.66, -.06)	(-.73, -.12)	(-.71, -.23)	(-.86, -.54)
old wizard	-.088	-.554*	.059	-.613**
	(-.57, .56)	(-.80, -.12)	(-.45, .52)	(-.88, -.22)

N=118, *p<.05, **p<.01 (2-sided), Bootstrap (1000) 95% CIs reported in brackets

Appendix F
Research articles

1. Sengpiel, M., & Wandke, H. (2010). Compensating the effects of age differences in computer literacy on the use of ticket vending machines through minimal video instruction. Occupational Ergonomics, 9(2), 87–98.

2. Sengpiel, M. (submitted 2014). Teach or design? How older adults' use of ticket vending machines could be more effective. Transactions on Accessible Computing

3. Sengpiel, M. (submitted 2014). Too old to use IT? User characteristics and the effectiveness of inclusive design. Universal Access in the Information Society